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Identification of Landscape Site Development Criteria and Compilation for Fossil Fuel Electric Power Plants Applied to a Critique of Huntington Canyon Power Plant, Huntington, Utah

Thomas Franklin Manns II

IDENTIFICATION OF LANDSCAPE SITE DEVELOPMENT CRITERIA AND COMPILATION FOR FOSSIL FUEL ELECTRIC POWER PLANTS

Applied to

A CRITIQUE OF HUNTINGTON CANYON POWER PLANT

HUNTINGTON, UTAH

by

Thomas Franklin Manns II

A thesis submitted in partial fulfillment
of the requirements for the degree

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Thomas Franklin Manns, II

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ABSTRACT

Identification of Landscape Site Development Criteria

and Compilation for Fossil Fuel Electric Power Plants

Applied to a Critique of Huntington Canyon Power

Plant, Huntington, Utah

by

Thomas Franklin Manns, II, Master of Science

Utah State University, 1974

Major Professor: Gerald Smith
Department: Landscape Architecture and Environmental Planning

This thesis project will explore the landscape site development of fossil fuel steam electric stations as it is presently practiced by electric utility companies, to determine what architectural, engineering, aesthetic, and climatological problems are being created through the engineering requirements acting upon the site during site development and construction phases of power stations. It will identify typical problem areas that can be resolved by the Landscape Architect through the practical application of landscape architecture principles, the design use and influence of plant material, topography, and the environment. Design criteria will then be formulated for the site development of steam electric stations.

The design criteria thus gathered will be applied to a critique of Huntington Canyon Electric Power Plant to determine the effectiveness and degree of success of the criteria.

(229 pages)

CHAPTER I

ORIGIN AND NATURE OF PROBLEM

It is common knowledge that following the Industrial Revolution, the continuing technical development, with its concomitant rise in wages and living standards, brought about increasing demands for power, food, fiber, housing, consumer goods, and services. In the effort to answer these demands, agriculture and industry grew by leaps and bounds and have undergone tremendous changes. In the process, much of the ecological balance of the world has been changed.

World-wide business is the name of the game, and the profit motive rules supreme. The investors, public or private, want and demand a return on their investments. Corporations have burgeoned and the larger ones are usually public, i.e.; their stock is sold on the open market.

Concomitant with modern industrial growth, and necessary to it, was the burgeoning demand for electrical power. Utility companies which supply the ever-increasing electrical power requirements of our homes, farms, businesses, and factories have grown apace and contribute their part to the overall problems plaguing our planet.

Few modern businesses, industrial or agricultural, could function without a source of energy or power, usually electricity. Electric power companies are corporations, and like other industries, they are governed by a chairman and a board, whose main purpose or goal is to turn a continuous profit for their stockholders. The maximum yearly profit is regulated by governmental agencies, and many of the utilities are hard pressed to make even the profit allowed because of higher costs for each unit of power, labor, maintenance parts, initial equipment, and research and development (R & D). Higher interest rates on borrowed money, and greater difficulty in obtaining short term and long term bonds from banks also tend to hold profits down (Hunter, 1971, public talk at USU).

Since the investors are interested mainly in one thing, how much they are making on the invested dollar, such things as environmental concerns are not too high on the investors' list of priorities. Although the environmental impact may be a major consideration, the executives and staff of individual power companies must be concerned primarily with turning a profit and oftentimes aesthetics are given a low priority.

Thus, indirectly, it is often the investor who actually impedes the development or addition of environmentally oriented design, engineering, and landscape architecture to power plants.

It is conventional wisdom that profit is the yardstick of industrial and corporation progress. All components of a business must be listed as units and each unit must be assigned a priority, a value, or a number if adequate cost accounting is to be worthwhile. By this method all things: functions, elements, components, and services of a particular business are judged. In this context, environmental concerns and aesthetics are often ignored because it is difficult to assign concrete values to them.

Rapid and continued expansion of technology has badly polluted the removable resources of our planet. Worldwide, the air, rivers and streams, the oceans, and even the soil have suffered because of indiscriminate waste. In the last ten years a growing concern has developed over water pollution, air pollution, the despoiling of the nation's natural resources and gross misuse of land masses.

With power demands doubling every ten years and the legal requirements that electrical power be provided as economically as possible, power companies have been concerned chiefly with speed, efficiency, reliability, and thrift in constructing power plants, transmission lines, substations, and distribution lines (Smith, 1971, personal interview).

These purely economic considerations, however, have resulted in concomitant damage to adjacent land areas, watersheds and waterways, game and fishing areas, recreation areas and historical sites. One of the most highly publicized examples is the widespread use of stripmining to provide coal for power plants, denuding vast areas of land.

Much damage also is brought about in the design stage by inadequate planning. Because of this, a power plant or segment of a transmission line may be located on an inappropriate land area. Or during construction phases, environmental damage may occur because of unwise construction practices and unenlightened management-level decisions. Site damage may occur in the form of erosion with the resultant loss of trees, ground cover, and topsoil (Patrick, 1968).

Statement of the Problem--Scope

Until the last few years, power companies seldom consulted with landscape architects about environmental problems inherent in the construction of power plants and their power transmission systems. It has been the recent practice to consult a landscape architect only after construction operations are completed and the public has been aroused because local scenic values have been violated. The landscape architect is then called in to alleviate the problems which pragmatic engineering has caused.

The typical electrical transmission system consists basically of four major components:

1. The power plant or electric power source.
2. High voltage transmission lines and right-of-way to move this power to market.
3. The substation, where high voltage electric power is reduced to usable low voltage currents. And;
4. The distribution system, usually consisting of lines, poles, and transformers which distribute the electricity to the home, business, farm, and factory.

Definition of visual pollution

Of these component parts, the greatest contributor to water, air, and visual pollution is an electric power plant, where the generators are driven by steam turbines. These fossil fuel steam electric stations burn either various grades of oil, coal, or are nuclear powered. Often they clash with their surroundings in whatever geographical region they are located. This thesis will address itself principally to the visual pollution problems associated with coal burning power plants. Such plants are guilty of visual pollution because of their apparent unorganized juxtaposition of large and small scale structures spread over relatively vast land areas, and because of the obvious factors associated with smog, including light scattering, and particulate matter resulting from stack emissions, not to mention health hazards, collectively called air pollution.

In many cases, little if any attempt has been made to integrate the structures to the site, or to aim the site development toward environmental, aesthetic, or intrinsic goals. Plant material is frequently very scarce if not nonexistent. This attitude is understandable in the time frame and in light of world conditions at the time of construction, but can no longer be tolerated.

Better planning--less cost

The Director of Environmental Development for Pennsylvania Power and Light Company, Quentin H. Smith, admitted to the writer in a recent conversation, that this procedure (the power industry policy of bringing in the landscape architect after the mess is there), is frequently less successful and certainly more expensive than it would have been to design and construct initially with plant material, topography, aesthetics and environmental design principles in mind. He stated that in fact:

> the basic problem confronting the electric utility industry until recently has been the internal decision, in the face of pyramiding demands for available dollars for the basic construction and maintenance needs, to admit that it is also necessary to make allowance for environmental considerations. (Smith, 1971, personal interview)

Smith (1971) suggests that early, professional planning saves money/costs less.

> The electric utility industry faces an environmentally aroused general public. The questions being raised are difficult to answer to the satisfaction of the public and oftentimes adverse reactions cause delays that may create critical shortages. The industry must acknowledge by policy and deed the public's right to insist upon environmental protection. However, no less important is the general public's duty to acknowledge that the principal function of this industry is to supply energy at a reasonable cost where and when it is required. What remains to be defined then is the balance between these two significant concerns. Energy must be supplied and the environment will be protected. (Department of Interior, 1970, p. iv)

This statement by the Department of Interior illustrates that delay costs money, therefore if prior planning eliminates delay, planning saves time and money.

Although much literature has been turned out covering most all of the environmental problems and considerations affecting fossil fuel steam electric plants, little or nothing has been done up to the present time to define the elements and procedures for the upgrading and integrating of the aesthetic image of fossil fuel steam electric power plants. Far less has been done to define the method of incorporating the altered site into the existing environment with the least possible intrusion and detrimental results to the ecology of the site. It would seem that this function would especially lend itself to the expertise of landscape architects.

It has been this writer's observation and experience that the people engaged in the site development of the electric power plant could contribute incalculably to its aesthetic improvement. The visual and functional problems of power plant site development can be solved by applying well-established topographic and planting design principles to develop planning and design criteria for solving functional, aesthetic, and visual needs and objectives of the electrical power company. Therefore there is a need for a book of guidelines, or a handbook of design criteria for fossil fuel electric power plants.

Summary--what is the problem

The following is a summary of the previously mentioned problems.

1. Need for the expertise of the landscape architect early on: There is a definite need for the landscape architect or environmental planner to be brought into the process of industrial planning at the very earliest stages, so that the site development and site planning can proceed in an orderly, logical, and programmed fashion. Thus costly environmental errors can be avoided by (a) conforming to a master plan, and (b) being aware through early inventory and analysis of the postive aesthetic and environmental aspects of the site, thus avoiding their destruction, and the negative aesthetic and environmental aspects of the site, thus providing the opportunity to change or remove them during heavy construction operations.

2. Lack of unity: Visually there is a definite lack of unity in the layout and plan of the power plant components, with obvious or apparent disorganization or unorganized juxtaposition of components.

3. Non recognition of two distinct and separate scales: Planners have not recognized the existence of two distinct and separate scales inherent in the new giant space age industrial complexes.

4. Power plant structures are not related to the site: Power companies are unaware of the ramifications of the environmental impact of the structures to the site visually.

5. Power companies have no general guidelines: Power companies or the power industry seemingly has no general guidelines for the landscape site development of the power plant, and no inter-industry communication concerning the matter.

6. Engineers sometimes are unaware of visual design possibilities: Engineers are often seemingly unaware of the visual design opportunities and high quality possible, in keeping with the highest traditions of their profession, regarding power plant structures.

7. Limited or non use of the functional properties of plants: There is frequently an improper or inadequate use of plant material to integrate structures to the site, or a complete unawareness of the functional uses of plant material, their application in erosion control, healing construction scars, and ability to greatly reduce the environmental impact and stress of power plants and other industrial complexes on sites. The major, generally recognized functions of plant materials are: Engineering, Architecture, Climatology, and Aesthetic.

8. Positive impact of aesthetics is not taken into account: There is a general indifference on the part of power industry decision makers to the

positive impact of aesthetics, partly because of a lack of funds, partly because of refusal to see the problem and/or give it importance, and partly because of the difficulty of assigning quantitative value to the components. There is a need to upgrade the corporation/industrial image.

9. Inadequate planning and delay costs money: Because of the failure to recognize the aesthetic environmental problems (visual pollution), there is often no planning done until after construction programs are carried out, and then the disaster is seen. Therefore money, time and positive environmental features are lost. It is usually much cheaper to make and change plans on paper than to make or change them in the field, after the first plan or non-plan has failed.

10. Topography: There is failure to take advantage of strong topographic features and qualities, which will tie industrial structures into the site and environment, and failure even to recognize the possibilities.

11. Conflicting public demands: Power plants cause visual pollution (see pp. 4 and 5), but there is, at the same time, increasing consumption of electricity by the public.

Objectives

The general purpose of this thesis will be to consider the basic fundamental environmental considerations, upon which power plant site planning, design, and construction are based, and the special problems involved in the landscape site development of power plants.

Functional and aesthetic problems caused by power plant construction are many and complex. Certainly the solution of all of them is far beyond the scope of this thesis. The specifics of how a power company selects a site are usually confidential in nature. However, there are problems inherent in and created by present site development practices that are neglected and widely ignored in industry journals and publications. But, site development information and documentation is readily available, although widely scattered.

There is enough information available to discuss those site selection fundamentals necessary to any valid evaluation of site development and resultant environmental impact.

The specific purpose of this thesis will be to compile and develop guidelines and design criteria for the landscape site development of steam electric power plants. This concept is not only for the enlightenment of designers, planners, and architects, but also for the enlightenment of the power industry leadership, executives, division heads, and engineers involved in power plant planning, design, and development.

<u>Summary of objectives</u>

1. To identify and develop guidelines or design criteria for the site development of electric power plants and other industrial complexes.

2. To determine an appropriate approach or concept by which to attack the industrial visual pollution problem (see pp. 4 and 5).

3. To determine and define the basic components and/or elements of design in fine arts and common to all professional quality design.

a. To determine sound professional ways of using landform or topography.

b. To determine and categorize sound professional ways of using plant material to functionally perform in the following areas:

1) Architecture

2) Engineering

3) Climatology

4) Aesthetics

c. To determine an alternative juxtaposition and application of power plant components in terms of visual impact and thus point out to engineers and planners some other possibilities of their discipline.

d. To determine an appropriate evaluation, listing, and application of landscape architecture design elements.

e. To determine and analyze the following physiographic elements affecting power plant site development and to determine how they affect design criteria:

1) Topography

2) Climatology

3) Plant material

4) Geography

4. To examine site conditions of Huntington and consider how to take advantage of these natural features, in order to determine ways, approaches, or

methods of design and site development guidelines by which to develop the site without destroying the ecology and natural beauty of the site.

5. To apply this design criteria in a critique of the Huntington site to determine the relevance and degree of success of the criteria.

6. To develop and compile material for guidelines to assist in developing a handbook of design criteria for landscape site development for steam electric power plants.

One specific application of this thesis is to relate these important fundamental considerations to one particular power plant located in south central Utah. A critique of the Huntington Canyon Power Plant will provide a model or case study for applying the general landscape site development guidelines, for the verification and testing of the objectives.

The aesthetic design criteria and guidelines will be formulated through the media of landforms (topography) and plant material. The power plant structures will be analyzed, broken down to their component parts. Major consideration will be given to the positive conservation value of this design criteria.

Procedure

The majority of site selection problems from the viewpoint of the power companies (insofar as the present technology allows) have been solved or are in the process of being solved. These land use problems, construction procedures, and engineering requirements are already published, but are not reaily available to the public. Some of these are:

1. Electric Power and the Environment, a report sponsored by The Energy Policy Staff, Office of Science and Technology, Washington, D.C. 20506, August 1970.

2. Working Committee on Utilities, a Report to The Vice President and to The President's Council on Recreation and Natural Beauty, U. S. Senate, Washington, D. C. 20510, Dec. 1968.

3. Considerations Affecting Steam Power Plant Site Selection, a report sponsored by The Energy Policy Staff, Office of Science and Technology, Washington, D.C. 20506, December 1968.

4. Engineering for Resolution of the Energy-Environment Dilemma, Committee on Power Plant Siting, National Academy of Engineering, Washington, D.C. 1972.

and others.

Terms will be explored and defined in two categories: First, the category of general information concerning (a) power plant components, and (b) common landscape architecture, environmental planning terms and concepts; second, the category of basic fine arts design principles, integral to and inherent in any kind of professional quality design, engineering, or achitectural planning/endeavor.

Personal communications between the writer and electric power plant officials will also be quoted in an effort to supply an understanding of the needs and objectives of power companies.

Next, visual, planting and land form design principles that can directly influence power plant site development will be compiled. By noting the visual and land use problems generated by present construction practices in building power plants, guidelines for solving these problems can be developed.

Physiographical factors will be examined and reviewed, as they affect steam electric power plant site development guidelines and design criteria.

Finally, these principles and guidelines will be applied to the Huntington Canyon Power Plant of the Utah Power and Light Company.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this chapter (Review of Literature) is to show a cross section of the best thoughts, ideas, studies, and work that has been done to date toward the collecting of data and formulation of site development criteria for industrial sites. Work, studies, and writing have been chosen, from a wealth of material, leaning heavily toward the subject of power plants because it will be more directly related and therefore more meaningful.

The landscape architecture/power plant literature will be adhered to because: (1) it is available; (2) it leads to the general goal of power plant landscape site development (LSD); (3) the important role and expertise of the landscape architect needs to be stressed; (4) a comprehensive study of this type is urgently needed at the present time as nothing now exists as a recognized industry-wide guideline, but more and bigger power plants are being built every day without benefit of guidelines.

These various studies and publications will be scrutinized to determine their inadequacies, if any, and to see if a more meaningful way of approaching LSD can be developed, in order to establish the base for LSD criteria.

Other criteria for selection

To achieve this objective, four competent authors/authorities have been included in the review of literature. The criteria for selecting these authorities for this chapter are: to get a diversity of views and locations, spotting across the country and the world.

1. Sylvia Crowe (SC)--The Landscape of Power. Sylvia Crowe (England), because she was one of the first landscape architect writers to address herself, early on, to the problems developing in the electric power industry and the environment. The reason for this was that England being very small in total land area compared to the U. S., an island with nowhere else to go for more land/environment, has come to the critical point far more rapidly and earlier, with environmental problems magnified many times, because of the critical need for electric power, water, coal, and the critical lack of new sites and land area.

With the inclusion of England the review of literature becomes international.

2. Lawrence Halprin (LH)--The Trojan Nuclear Power Plant Master Plan. Lawrence Halprin (California) is selected because here is perhaps the most widely recognized and well-known expert in landscape architecture and environmental design. Also he has been commissioned to design and carry out some of the largest projects in the U. S. Halprin is located in California. California tends to be in the forefront in many areas of design because of several factors: a highly industrialized oil industry, a year-round outdoor season, large population, large land area, agricultural and mineral wealth, diversified climate with a consequently wide selection of native plant materials, and an active interest by its citizenry and political leaders in environmental problems.

The Trojan site being located in Oregon, represents the West Coast and therefore another point of view. It also represents different ecologic environment (wet) with considerable more run off available than here in Utah.

3. Johnson Johnson and Roy (JJ & R)--Substation Site Selection and Development. Johnson Johnson and Roy (Michigan) is added because JJ & R is a recognized expert in the field of landscape architecture attempting to develop meaningful answers to the electric industry problems. JJ&R is a relatively large and well thought of/eminent office and one of the first in the U. S. to come up with a first class brochure on the general subject area. They also qualify as a Mid West/East Coast point of view, Ann Arbor/Chicago area.

4. Gary O. Robinette (GOR)--Plants/People/and Environmental Quality. Gary O. Robinette (Washington, D. C.) is added because, being from Washington, D. C., he represents the East Coast point of view. (Note: Much of GOR's study appears to be from California.) Robinette also represents the landscape architecture field in general, because he is the Executive Director of the American Society of Landscape Architects Foundation. Here an entirely different point of view is presented, because Robinette is dealing with plant material specifically. He sees an urban/suburban crisis of a rapidly-changing society which is losing many valuable traditions, qualities, and elements because of the use of only one criteria: Science/Economics/Statistics = MONEY.

Preface

England is a relatively old industrial nation, limited in land area that has already faced many of the environmental problems currently plaguing the United States.

Highly industrialized, yet very small in comparison to the U. S., England reached the critical point with regard to resources and electrical power far more rapidly and earlier.

In the first half of the nineteenth century, each power station built to supply industrial power or municipal lighting was at most no larger than a small dwelling--the reason being that each separate use, i.e., smelter, textile mill, home lighting, was powered by a separate generating station. Thus there was no demand for a large station, and these small units fit right into the scale of the surrounding village, town, or factory, where often there were other much larger buildings nearby.

However, toward the latter part of the nineteenth century and on into the first half of the twentieth century, electrical development and associated industrial and scientific advances created a demand for more and bigger industrial site development, and correspondingly larger power stations and sites. England soon found that sites for power plants were in short supply.

Meanwhile, back in the U. S. A., little if any real thinking was given to resource and environmental planning until the last decade. Suddenly in the 1970's the alarm sounded.

According to Freeman (1970), while increasing numbers of people are critical of the effects on the environment of the construction of electrical generating and transmission facilities, the population as a whole is increasing its consumption of power at a rate five times faster than the actual population growth.

The desire, maybe even the need, for more power is at the root of the problem.

The problem, as Freeman (1970) points out, is to reconcile these concerns dealing both with the more obvious elements of smoke, gases, and heat, and also with the concerns over the land used for electrical power and transmission facilities. The electric power industry, while only one of many contributing to the pollution of the environment, is perhaps most easily seen in its effects by the public, as well as being the largest company in the nation in terms of capital invested.

Freeman also went on to say that:

> Fossil fueled electric plants discharge almost 50 percent of the sulfur oxide pollutants, 25 percent of the particulate and approximately 25 percent of the nitrogen oxide emissions emitted in the United States. Although motor vehicles discharge nearly 60 percent of the total pollutants into the atmosphere, they are not a significant source of sulfur oxides. (Freeman, 1970, p. 3)

Freeman (1970) goes on to say that not just the air pollution factors need to be considered. Visual pollution is a very real problem. One must realize that vast areas of land are required for generation and transmission facilities. A 3000 megawatt nuclear plant takes up about 400 acres and a similar coal plant could take up as much as 1200 acres. Our overhead transmission line rights-of-way presently use about 4,000,000 acres of land. This gives a pretty fair idea of the parameters/immensity of the land area involved.

However, nuclear plants are far from popular and few of these scheduled for construction have been completed. Freeman (1970) makes the point that we can judge the future by the past. In the next 20 years the capacity for producing electric power will triple, requiring nearly 500 sites, each capable of producing more than 500 megawatts (MW). Most of these sites will be able to produce 1000-4000 MW and some as much as 6000 MW. However, many of the present sites can be redeveloped and expanded making it necessary to build only about half of the estimated sites needed to meet the requirements of the future.

Within the United States there are approximately 3400 electric power generating plants. Of these, 1000 are steam-electric with the other 2400 about evenly divided between hydro and internal combustion generation.

Actually, according to Freeman:

> Steam-electric generating capacity constitutes nearly 80 percent of the industry total at present and produces nearly 85 percent of the kilowatt-hours generated. It is projected that steam-electric generating capacity (fossil-fueled and nuclear) will increase to 84 percent of total capacity over the next 20 years and, by 1990, will be producing about 93 percent of the kilowatt-hours used. (Freeman, 1970, p. 52)

Freeman (1970) states that the problem of siting in the future will not be one of dealing with a large number of small sites, but of handling adequately the small number of vast plants in terms of low cost, reliable power and protection of the environment. Each of these plants will require $300 to $400 million dollars and together they will cost more than $80 billion dollars, an investment very much affected by public concern.

It is important to stress that as these sites, with an average on-site cost of $380 million, will be relatively few (500 sites), considerable time and money spent on design, analysis and site development are feasible and justifiable because of the immensity of the potential impact of these industrial complexes.

Sylvia Crowe--Design Concepts

Sylvia Crowe, an English landscape architect, considered the problems developing in the English electric power industry. In her book, The Landscape of Power, she states the premise that "A humanized landscape must reflect the society which is settled upon it." . . .

> Inevitably the landscape must change if it is still to reflect the nation's life, for it must now reflect the growing mechanization of the economy, the greater diffusion of wealth and knowledge throughout the community and the increased mobility of the population. While these changes have come gradually during the last century and a half their tempo has now quickened and to them have been added new developments, which are not only influencing art and landscape all over the world, but which pose a problem to the whole of civilization. (Crowe, 1958, p. 11)

Crowe (1958), at first, was a voice in the wilderness trying to call for developing a tradition of design that could be applied to the cluttered landscape of the English countryside. She noted that there are certain basic differences between traditional landscape design and that which would need to be applied to the particular needs of the power industry.

For one thing, she points out, present-day construction is far larger in size and number than that of a previous generation, and is also more ubiquitous, being found throughout the countryside. The life of the country, in fact, is more and more one of "movement and mechanization."

Tradition of design/art and science

The challenge is to build and/or develop a tradition of site development (LSD) based on the general area of art and science. While the technical engineering aspects of power plant and other industrial site development have surged ahead, the physical sciences and the arts have not made a corresponding contribution to the problems of industrial siting and site development. This may be largely due to the fact that these particular physical sciences and arts are relatively new fields and just growing to the point where they can make a strong and valid contribution to the answers to these problems. Another factor may be the time lag--problems are not recognized until after the technology has been applied.

Scale and shape

In defining the various design elements that should be considered, Crowe (1968) drew attention to scale and shape.

The latest stages in the evolution of human discovery have brought man a completely new problem in the scale of individual structures and land mass involved and affected by industrial site development, but the designer is also faced with a new and exciting range or spectrum of shapes. Machines were originally a supplement to manual labor, but now have evolved to serve as extensions of the brain. "Man's intellect has extended beyond the exploration of the earth, to the harnessing of cosmic forces." (Crowe, 1958)

Proportion and congruity of form

The relationships of one object to another are actually the basis of urban design. Generally referred to as the laws of proportion and congruity of form, these principles also apply to such vast construction projects as the power plants of the future.

Crowe offered one idea of scale when she wrote: "The standard of height in a landscape is that of a tall tree. Once this is overtopped, a new scale is introduced, and further increase of height has relatively little significance." (Crowe, 1958, p. 85)

New tradition of design

She also commented that:

> If either life or the landscape is to retain its depth, the richness of variation must somehow be guarded within the unifying framework. We need a translation on a wide scale of the laws which have governed design in all great landscape architecture traditions. (Crowe, 1958, p. 20)

The essence of landscape, according to Crowe, is its rhythm--an artistic concept. The foundation of this rhythm is the continuous flow of contours in undulating country that unites all objects within it. "This conception of a flowing, unbroken landscape, viewed as a whole is the background against which design of the new structures, their siting and their zoning, can be considered." (Crowe, 1958, p. 25)

Crowe (1958) goes on to say that when buildings, both large and small, are introduced to the landscape the effect upon the viewer is immediate. Such constructions are either humanized or elemental (cosmic). For example, humanized buildings are those constructions or buildings which basically are self-centered or enclosed, whether with a roof or open to the sky. The natural landscape, however, flows freely.

Elemental buildings she defines as such things as lighthouses, dams, bridges, and roads that fit into their setting. They are simple in form and functional, and can easily be absorbed into the pattern of the landscape (Crowe, 1958).

Crowe admits that:

> The elemental structures sometimes disrupt the landscape, but they need not do so. Their lines can join in the rhythm, and make part of the landscape pattern. In scale, immense humanized buildings springing up starkly from the landscape, can be more overpowering than an elemental structure of comparable size, because it is possible to feel detached from the latter, but not from the former. . . . The smaller humanized buildings may fit in as part of the pattern of a humanized landscape. But the larger constructions, particularly in the more open landscapes, are more easily absorbed if their form suggests an extension of organic nature, rather than the imprint of human proportions. (Crowe, 1958, p. 17)

She feels that the ideal is to link nature and construction together into the rhythmic flow of the true landscape.

Crowe (1958) goes on to say that if these elemental or cosmic structures are seen together with the small rectangles of subsidiary or auxiliary structures, or even worse, are surrounded by the fenced square enclosure which effectively breaks the rhythm of the surrounding landscape, the desired effect is lost.

Construction shapes have essential forms that fall into certain categories. Some are essentially solid, planted firmly on the ground. Essentially, they appear to grow from it, a part of it.

Crowe (1958) points out that in any humanized or small-scale landscape, the largest of these solid structures are over-powering, whether town or country. The best reconciliation is to introduce or impose a zone of complete simplicity between the structures and any area of human scale and/or intricacy. This zone of simplicity may be composed of open ground, water, or tree mass. The degree of reconciliation depends on the proportion of this zone of simplicity to the height of the structure.

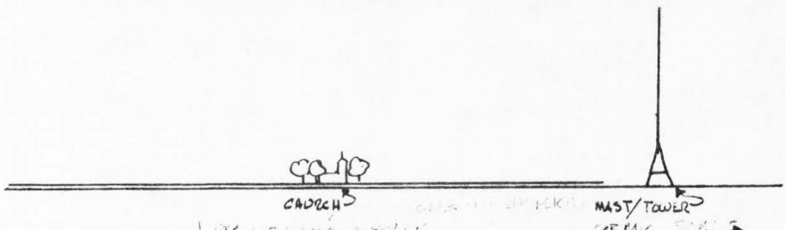


Figure 1. Zones of simplicity. (Crowe, 1958, p. 45)

According to Crowe (1958), if this space (zone of simplicity) is broken by scattered trees or buildings, the effect will be nullified, because these elements will serve as stepping stones to the viewer's eye, and tend to reunite the two scales between which a complete break is required.

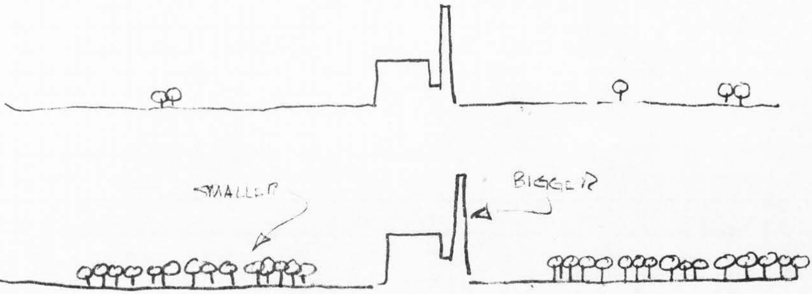


Figure 2. Stepping stone versus mass PM.

She further points out that the effect on the landscape of any further increase in height is far less important, once a structure exceeds 100 feet, than an increase in bulk (Crowe, 1958).

Zones of influence

In considering the relationship of buildings to landform, the landscape architect must concern himself with zones of influence. In the case of a corporation or industrial plant, that particular construction exerts some type of influence on the surrounding area. This may consist of ancillary, smaller structures, noise, smells, smoke, dust, or liquid wastes. Some badly planned structural complexes even cause mental strain because of their clashing relationship with the natural environment.

Zones of influence extend from every construction in waves of diminishing intensity. First is the overwhelming artificiality or urbanization where most of the senses are assaulted, then the zone of visual domination, and finally, the zone of psychological effect.

The environmental planner or landscape architect is in a position to minimize the effects of these zones of influence to a much greater degree if they are consulted early on in the industrial planning process. Massed plantings, open spaces, architectural manipulation of structures housing pollution-producing machinery are processes shaping the landform.

Lawrence Halprin--Design Concepts

Wholistic approach

Lawrence Halprin, a widely recognized and well-known expert in landscape architecture and environmental design emphasizes the wholistic approach. Halprin, a Californian, was commissioned to carry out the environmental design for the Trojan nuclear power plant located on the Columbia River downstream from Portland, Oregon.

Definition of "wholistic" is: overall view, or taking into consideration, at least, all ecological factors affecting the site development: biotic communities, topographical assets, restrict development, full utilization of all resources of the site, and breaking down and clearly defining these use areas into: (1) industrial factors, needs, and functions; (2) recreational factors, needs, and functions; and (3) natural factors, needs, and functions. The objective of this is to preserve the integrity of the site.

Integrate forms

It is Halprin's contention that he has achieved the goal he set out to accomplish at the Trojan nuclear power plant, i.e., to integrate the huge industrial forms to the landscape in a wholistic way without destroying the integrity and continuity of the existing site.

Although the design was for a nuclear plant, the principles are equally applicable to fossil fuel power plants because both are massive constructions and have similar structures, forms, land area, layout, and requirements (water, etc.).

Wholistic approach possible only with cooperation of other disciplines

Halprin (1970) goes on to say that this kind of all-encompassing Site Development Master Plan and this "wholistic approach" is impossible without the help and cooperation of many experts in differing fields of knowledge. It is impossible for the landscape architect to do a creditable job without the cooperation of the architects and engineers from outside consultants, the leadership and staff engineers of the power companies themselves, and the cooperation of the design, construction, and engineering firms who collect the various necessary data gathered by men trained in many disciplines such as, agronomy, meteorology, hydrology, geology, topography, soils, cooling tower requirements and effects, and other climatological and landform requirements.

Data required for (LSD) also

This data is not only necessary for the successful design, construction, and functioning of the power plant itself, but much of it is desirable and necessary for the successful design and development of that portion of the site development for which the landscape architect is responsible, which is the overall, wholistic, ecological view of the landscape, or site environment.

Cooperation

Halprin's study is a case in point, illustrating the total involvement and cooperation of all of these disciplines and the need of bringing the landscape architects in on the project from the very beginning where they can be most valuable and effective.

Guide to other planning

Halprin sums up his viewpoint by saying that he hopes that future design approaches will incorporate or use this specific study as a guideline or springboard for their own specific power plant or other industrial site development program.

He also states:

> Underlying the Halprin approach to the planning of the site is a basic principle: any disturbance of the natural

> environment must be kept to an absolute minimum. Consequently, the preservation of the integrity of the site was a factor of prime importance. (Halprin, 1970, p. 7)

Letters that support the need for guidelines

To preserve the integrity of the site is apparently a constant, although extremely recent, theme in some areas of the electric power industry leadership, as evidenced by the quote by Mr. Darrell V. Menscer of Carolina Power and Light Co.:

> The criterion that Carolina Power and Light Company uses in landscaping its plant sites is to leave the site as close to its natural state as possible. (Menscer, 1972, letter)

Even though Crowe; Halprin; Johnson, Johnson and Roy; Robinette; and others have all published and attempted to develop a tradition of design for industrial landscapes, it seems that power companies are generally unaware of the present "state of the art," especially in regard to what other companies in the industry are doing in research and development on the subject. Instead, each company either:

a. develops its own criteria or landscape site development procedure independently of other industry R&R,

b. disregards design criteria and designs by default,

c. or has no use for design criteria because it feels that such criteria is unnecessary for their development program, and in fact is a bunch of nonsense and a waste of money.

Strength for this point of view is found in the following quote by Mr. Howard R. Palmer, Vice President of Dayton Power and Light Company:

> I am sorry to say that, to our knowledge, no landscape design criteria exists which would be applicable to each site development for fossil fuel steam power plants.
>
> I'm sure that you have found that the design criteria, to be applied universally, would have to be very general in scope whereas practice dictates that the plan for the landscape architecture must be specifically tailored to the particular facility and site. (Palmer, 1972, letter 20 June)

and also in the quote by Mr. Neil W. Plath, President of Sierra Pacific Power Company:

> Sierra Pacific Power Company at the present time has seen no reason for going to extravagant landscape projects in respect to its fossil fuel steam power plants.
>
> Both of our plants are sited in a stark, sagebrush, desert environment and I am completely at a loss to think what might be done to landscape them or do planting to break up their structural continuity. (Plath, 1972, letter 19 June)

Another quote emphasizes the point that perhaps the body of general design principles are being ignored because each site has its peculiar and particular problems. Mr. Arthur M. Williams, Jr., President of South Carolina Electric and Gas Company, says:

> While this Company is fully cognizant of the necessity of maintaining empathy with the ecology at both its fossil fuel, nuclear, and hydro-electric plants, as well as maintenance of suitable and desirable esthetic factors, I do not believe that there is any published Criteria as to procedure. You will understand that each of these plants now costs from one hundred to five hundred million dollars and is rather a "hand-tailored" facility. Our engineering staff is charged

> with the responsibility of seeing that the above factors are complied with and has, in the last few years, done a particularly excellent job.

The emphasis is on the point that no industry-wide design criteria exists, not even general guidelines, company wide. It also seems apparent that there is no inter-communication in the electric industry concerning design criteria or research and development along these lines.

Johnson, Johnson, and Roy--Design Concepts

Johnson, Johnson, and Roy Inc. (JJ&R) is a firm recognized as expert in the field of landscape architecture. The firm has developed an excellent reputation by coming up with meaningful answers for electric industry problems.

One of their studies, Substation Site Selection and Development, can be readily applied to power plant problems because many of the problems and principles for solving them are the same.

A brief preview of the basic concepts

The emphasis of the JJ&R study is:

POZ concept. First, to establish and define the concept of Primary Observation Zone (POZ), the point or points from which the viewer views the industrial structures (Power plants or substations).

Screening as a solution. Second, to propose the implementation of screening as the solution to industrial structures problems (substations). This concept holds true for the screenable structures of power plants (auxiliary structures), but it is not generally desirable to screen principal structures.

PM and TOPO as screening media. Third, JJ&R proposes that the screening problem is best solved through understanding the qualities and use of plant material and topography.

Aesthetics. Aesthetics is a visual phenomenon, peculiar to human beings. The primary concern is what is seen or perceived from the POZ by human beings. What is seen by the viewer, when perceived as non-aesthetic, is the visual problem. The POZ concept is therefore a way of approaching this visual problem, and the JJ&R solution would be to use plant materials and topographical forms to screen this non-aesthetic view.

Variations on the POZ concept as applied to power plants

First variation. While substations are generally viewed from only one localized area, generally the front, this may not be the case with power plants. It is possible to view some power plants from more than one local point, maybe even from any point on the compass and at varying elevations.

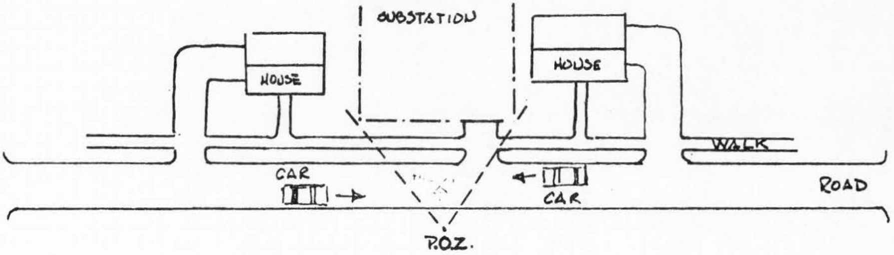
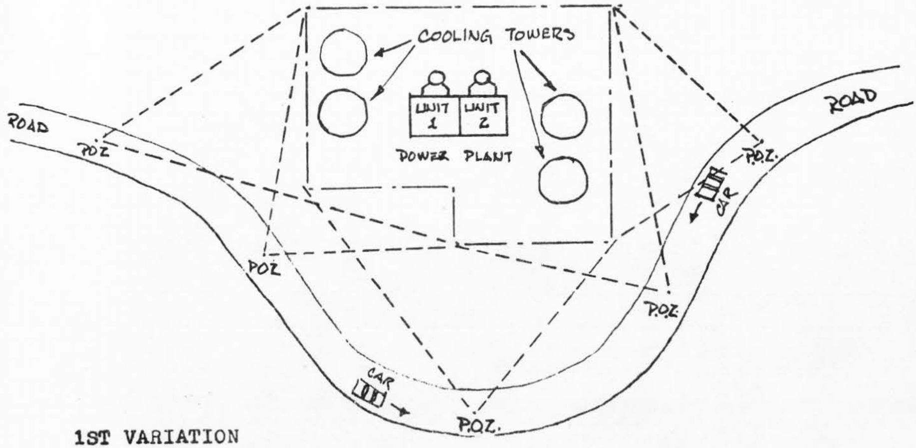


Figure 3. Typical substation.

This concept is illustrated by the drawing below:



1ST VARIATION

Figure 4. Typical power plant.

Second variation. As learned from Crowe (1958), there is another variation imposed by power plants--that of scale, illustrated in Figure 5. The scale of a substation is very small in relation to that of a power plant. Principal structures of substations are generally of a human scale, while the principal structures of power plants are of cosmic scale.

Third variation. The goal in developing a substation site is to screen the majority of the substation from view. This is not the total goal in the case of power plants but rather: the goal is partial or total screening, minimizing

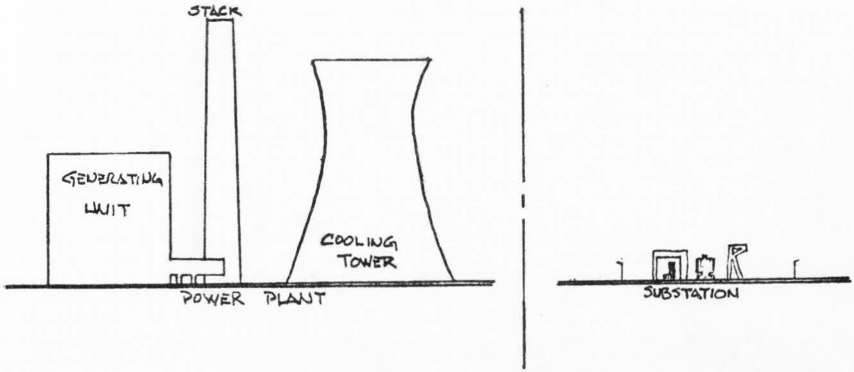


Figure 5. Cosmic versus human scale.

auxiliary structures, and at the same time softening, enhancing, and featuring to the best advantage the major structures, i.e., water cooling towers, main generating units, etc.

Principal screening zones

There are two principal zones inherent in the JJ&R POZ concept. These two zones are based on the yardstick of the eye-level of the average human being, the point, measured from the ground, from which he sees (approximately 6 feet).

Zone A relates to those structures or portions of structures that occur to view on and below eye-level, and continues 90 degrees downward to the feet of the viewer. The eye level zone is more easily buffered or screened because of its lower height, and because it can more easily be absorbed into the background. (JJ&R, 1969)

Zone B relates to those structures or portions of structures that occur to view above eye-level, and continues for several degrees of arc upward toward the zenith. This is generally horizon line or skyline and somewhat above. This area is almost always exposed, and is seen above the enclosing and protecting chain link fence. (JJ&R, 1969)

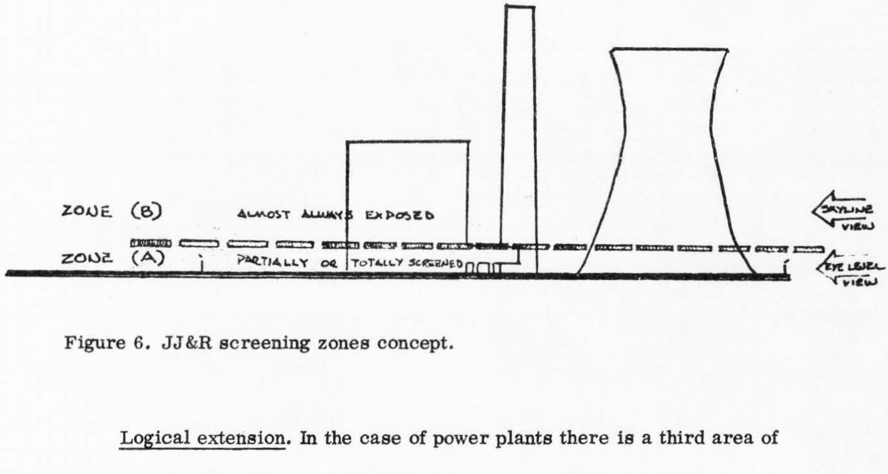
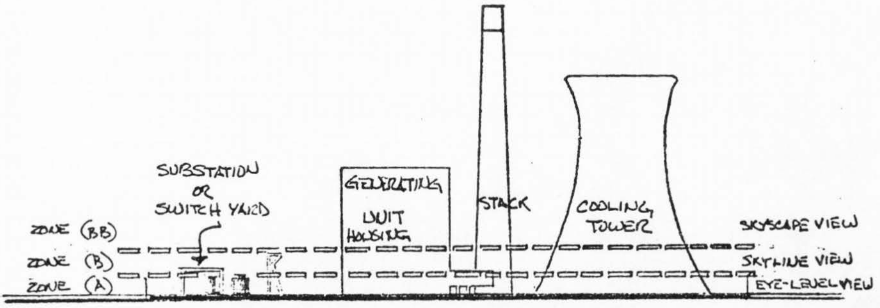


Figure 6. JJ&R screening zones concept.

Logical extension. In the case of power plants there is a third area of principal concern, which will be referred to as zone (BB)--skyscape.

Zone BB. This zone is the logical extension of the JJ&R concept of zone B. This area also requires special and separate treatment, and, in general is of third priority of the scale of difficulty. The reason for this is because this zone (BB), is comprised of principal structures on a cosmic scale. Principal structures in general do not require screening.



EXTENSION OF JJ&R CONCEPT TO ZONE (BB)

Figure 7. Extension of JJ&R screening zones concept.

Zone BB includes everything above zone B (say 5 degrees), to looking straight up, with one's head back. That would be 85° out of 90° from eye-level or horizon to zenith.

This zone is a somewhat arbitrary zone, in that sometimes it has a backdrop of mountains, cliffs, or similar terrain, but at other times it may be completely open to the sky, or any combination of these. What applies to zone B applies to zone BB, the main difference being that only the largest of land forms can have any diminishing effect upon structures in zone BB. Plant material, naturally, would have a minimal effect in background screening.

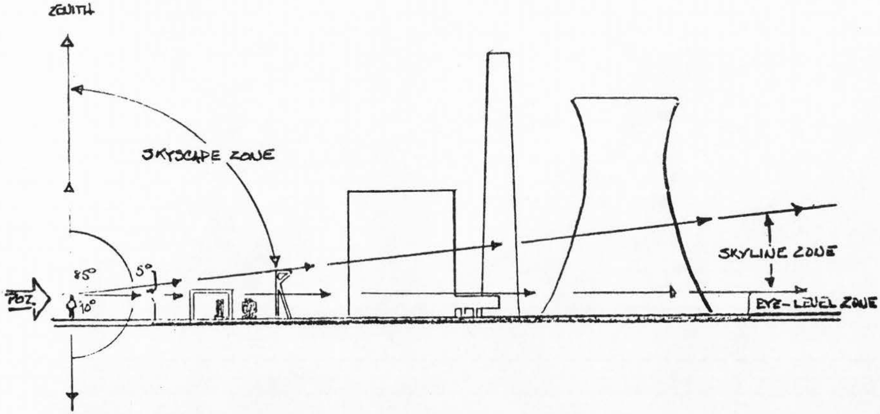


Figure 8. Screening zones in relation to viewer (POZ).

Effect of sun on POZ

When considering the POZ, the sun has a definite effect. If the POZ is facing the sun, the skyline view is diffused by the sun's rays and appears to recede. When the sun is to the back of the observer, the skyline view appears much closer, as seen in Figure 9.

Screening planes

The problem of screening is essentially concerned with two primary planes--the horizontal and vertical. Each of these planes can be manipulated to emphasize or diminish the visual impact of the structures.

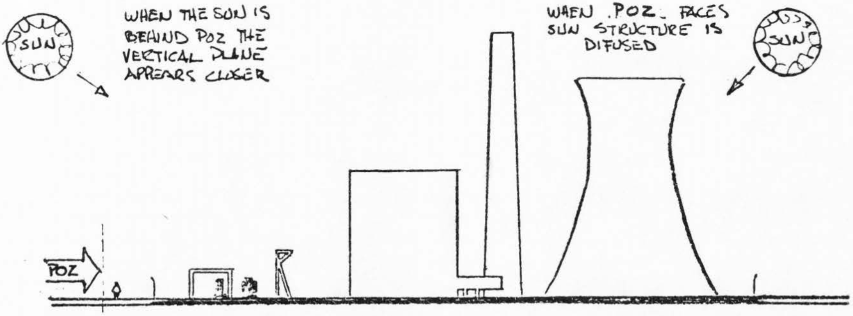


Figure 9. Effect of sun on POZ.

Horizontal plane. The horizontal plane is directly related to the set-back dimension, and affects the vertical plane proportionally, depending upon the set-back dimension from the POZ. For instance, the greater the setback dimension is from the POZ, the less impact the size of the power plant will make (JJ&R, 1969).

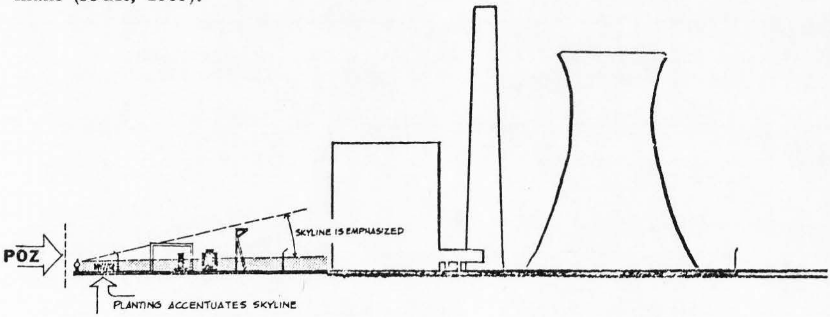


Figure 10. Low planting accentuates skyline screens eyelevel zone.

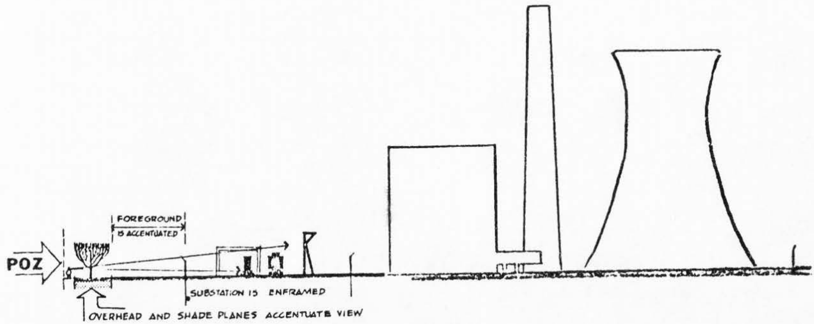


Figure 11. Overhead planting and shade accentuates view.

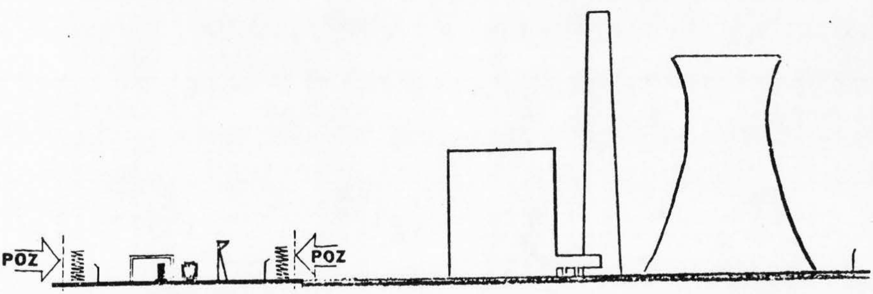


Figure 12. Maximum screening necessary when POZ is close up.

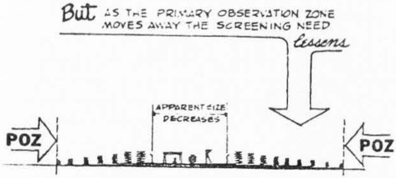


Figure 13. Minimum screening necessary when POZ is far off.

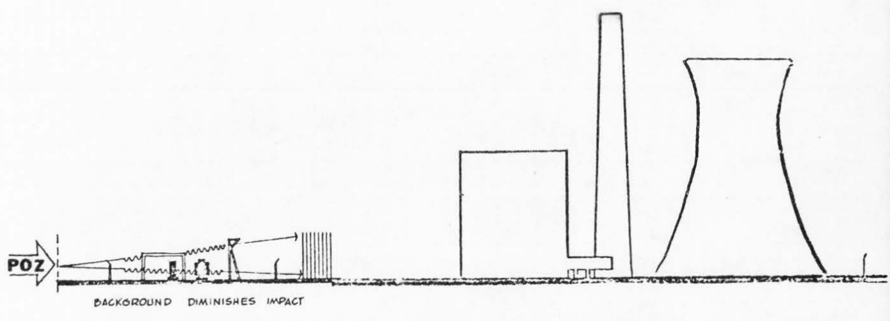


Figure 14. Background screening diminishes impact.

Vertical plane. Structures in the vertical plane can be used at high levels to good effect. Large trees in the background can reduce the visual impact of large structures, and topography itself can screen or absorb the impact of the structure (JJ&R, 1969).

Planting zones

In addition to the zones of sight, the JJ&R study (1969) distinguishes five planting zones because, as stated before, the emphasis of their efforts is directed toward the screening effect of plants and topography.

There are five basic zones for the use of plant materials:

1. Zone A is the area between the POZ and the protecting fence at eye level.
2. Zone B is the area above Zone A dealing with the skyline silhouette of the structures.
3. Zone C is the eyelevel background area.
4. Zone D is the skyline background area. The POZ is usually greater in height at this point.
5. Zone E is the area to either side of the major site development. (JJ&R, 1969)

Zone E is perhaps not a viable zone generally, except in those cases where the power plant is seen from only one major viewing point or area (POZ), as shown in Figure 15.

Zones BB and DD are merely extensions of zones B and D for the purpose of illustrating the screening demands or possibilities of the larger (cosmic) scale principal structures. Implementation of larger (taller) trees can be useful in some cases, in zone BB, close to the POZ, when the design goal is to screen the major structures. Only the tallest of landforms can be effective in zone DD and the use of plant material here is impossible except when landform

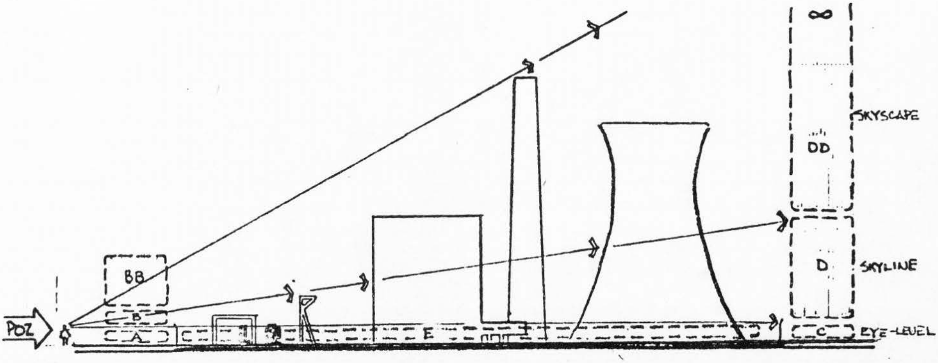


Figure 15. Planting zones.

is already in existence, and then plant material contributes to extending a consistent texture and color to the existing landform.

Influence of plant material

Plant materials of varying degrees of denseness can visually screen all these zones. The distance of the POZ to the power plant determines the height, degree of plant denseness, and the planting zone, as the closer the POZ is, the lower and more solid the plant material must be (JJ&R, 1969).

Design factors inherent in the use of plants are rarely understood.

1. The first is scale:

   A. Human scale is comfortable to the individual because he is not overwhelmed by the size of other objects/structures. In other words, a scale to which he can relate and be aware of refinement.

B. Environmental or cosmic scale is that dimension which involves the entire visual area from a given point. Within this larger dimension, detail is less important and individual elements are accumulated into one or more large impressions.

2. The second is texture:

A. Texture is another often confused design term that relates directly to plant material. Plants can readily supply differences in size and intricacy of the branch structure as well as size, color, and texture of the leaves. For example, plants with a heavy, dense, branch, and structure and large dark green leaves are heavy textured, whereas light open plants with small light colored leaves are fine textured (JJ&R, 1969, p. 18)

Plant materials also uniquely lend themselves to manipulation of form. They exist in almost any conceivable form but generally they vary from hard rigid, geometric forms to soft, light, informal, natural forms. Which form to use is influenced by the natural environment and the structures present. The more tailored, rigid, forms blend well with the urban community whereas the suburban community may require less plants, but they still should relate to the artificial and structured order of suburbia. Completely soft plant materials are naturally more compatible with the native countryside (JJ&R, 1969, p. 19).

B. Negative influence of texture: In keeping with the guideline to implement native plant material is the idea of using evergreen with evergreen, and deciduous with deciduous. In general, it is not advisable to introduce evergreen plant material into a totally deciduous site, and to a slightly lesser degree it is not advisable to introduce deciduous plant material into a totally evergreen site. The introduction of a foreign plant material will inevitably nullify or produce the opposite effect desired, i.e., draw attention instead of screen and blend. In the case where a mixture of evergeen and deciduous already exists, the point is moot.

3. Evergreens PM:

To accomplish effective, solid year-around plant material screens, evergreens are the obvious choice. Most of them have solid, clearly defined forms that are emphatic and command attention. Evergreens can solidly delineate the vertical plane as well as horizontal, if the plant takes that form, and visually bring each of these planes forward. Where the variety and color of seasonal change is of minor importance, these plants provide excellent, opaque screening close to the POZ. In addition, they provide emphatic focus, and solid massive forms with consistent texture.

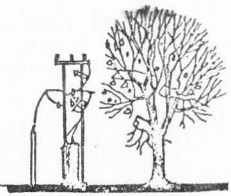


Figure 16. Equipment structure compares to tree structure.

4. Deciduous PM:

There are places for the deciduous trees and plants, however. In some cases, less opaque screens are required as the winter season advances. The tracery of bare tree branches can effectively screen the skyline. Usually, the less rigid plant forms provide an appropriate solution. Deciduous planting can offer a wide variety of texture, denseness, color, and form. A thorough knowledge of these characteristics coupled with a sensitive design awareness can make deciduous planting extremely effective (JJ&R, 1969, p. 15).

JJ&R (1969) points out that in the majority of cases the most effective and successful planting designs will be those where evergreen and deciduous plant material have been implemented, each in its own particular value.

5. Sound absorptive qualities of PM:

The JJ&R study acknowledges that sound is a component of the industrial environment and recognizes that plant materials are usually not effective as sound screens.

> Extensive experiments have indicated that plant materials although sometimes very effective as a physiological barrier, do not have the necessary absorptive characteristics to be a useful sound barrier. Evergreens will, of course, be somewhat more effective than deciduous plant material but still not approach the absorptive characteristics of earth berms or solid walls or screens having acoustical qualities. (JJ&R, 1969, p. 14)

The main emphasis of the whole study remains on visual screening and how to tie in the structures to the surrounding environment.

Influence of topography (landform)

Johnson, Johnson, and Roy do not in any way try to say that plants are the whole answer to industrial landscape problems. Quite the contrary, they comment: "Topography or landform, whether shaped by nature or by man, can be one of the most useful elements of the site to solve esthetic and functional site development problems." (JJ&R, 1969, p. 20)

The most important consideration is to examine the area surrounding the power plant to discover natural landforms that can influence the landforming and planting of the site itself. A hillside background, for instance, will influence the POZ. The diagrams that follow show the principle concern of environmental topography, and screening, and the effect of horizontal setback, and the background screen on the POZ.

Aesthetically, the landform within the site itself should harmonize with the environmental topography. The careful use of landform combined with plant materials can result in a meaningful site development plan, and the planting can often be less dense and numerous when combined with various kinds of landforms (JJ&R, 1969).

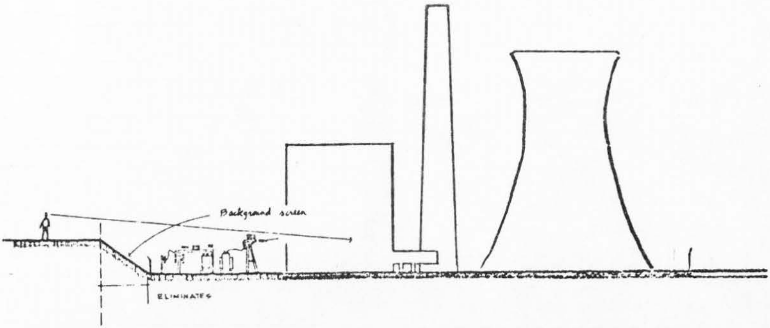


Figure 17. Depressed landform screens auxiliary structures.

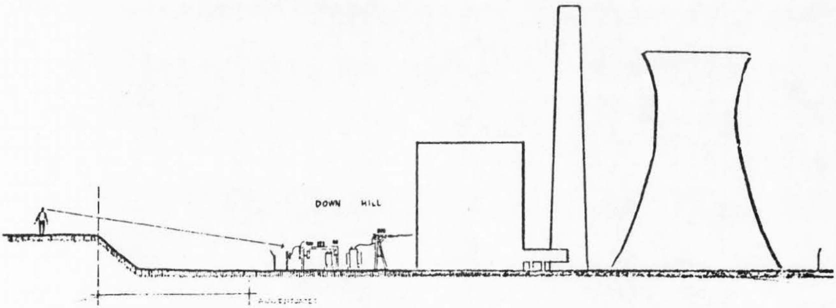


Figure 18. Depressed landform accentuates auxiliary structures.

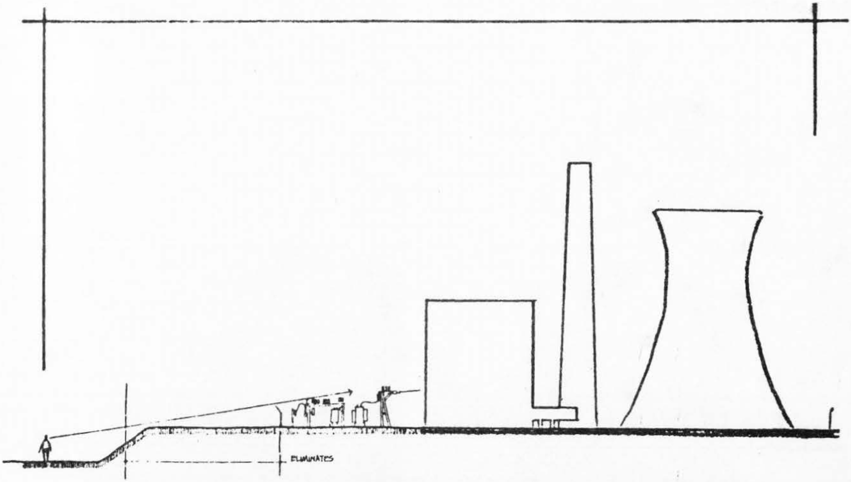


Figure 19. Raised landform screens auxiliary structures.

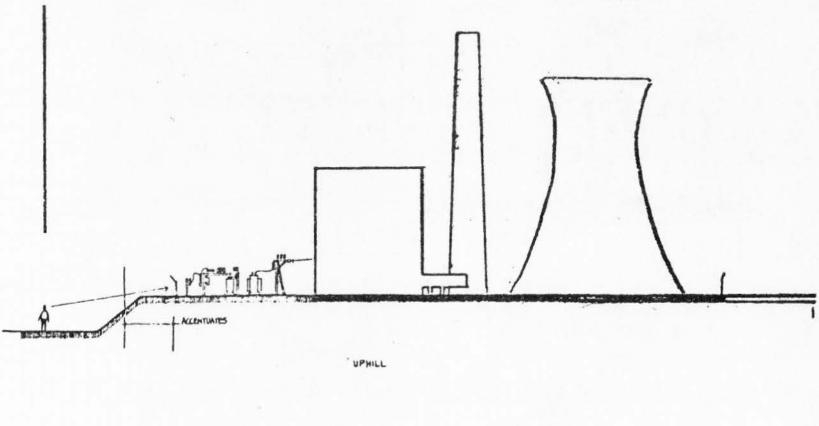


Figure 20. Raised landform accentuates auxiliary structures.

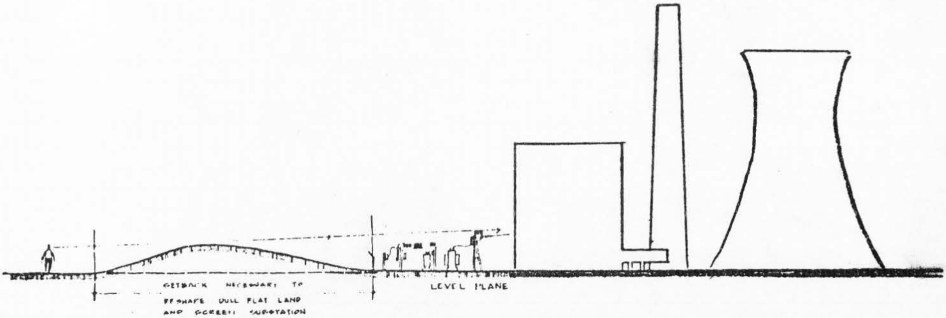


Figure 21. Combination setback and raised landform screens auxiliary structures.

Of course, the shape of topography varies with each situation. Gentle soft forms might be entirely fitting when the site is located in the wide open countryside. More tailored and sculptured forms might be compatible with the urban setting, however. One often overlooked use of topography is its value as a visual screen. Functionally, earth forms have the advantage of being permanent, positive and opaque visual screens. They can be constructed from normal onsite excavating operations. In addition, there is the advantage of appreciable cost savings that can be realized by utilizing cut material on site rather than hauling it away.

TOPO as effective sound absorber. In contrast to plant materials, compacted soil is one of the most effective absorptive materials for noise. Earth forms properly designed, dimensioned and located can substantially absorb or deflect sounds created by power plant operations.

Gary O. Robinette--Design Concepts

Gary O. Robinette, who lives in Washington, D. C., is familiar with the landscape architectural problems of the highly industrialized and urbanized East Coast. His position as the Executive Director of the American Society of Landscape Architects Foundation lends some support to his reputation as an expert in the use of plant materials in solving some of the problems of the urban-suburban crisis.

Functions of plant material in environmental design

Robinette faces up to one of the problems prevalent among environmental engineers. As he says:

> Plants are vestigial natural elements in an increasingly man-made world. Plants are now largely ignored by serious environmental designers because they have attached to them the stigma of "gardenesque," romantic, irrelevant, bucolic landscapes having nothing to do with the frenetic activity of the bustling metropolis or the scattered suburban sprawl. They are also, increasingly, a subjective component in a highly objective culture. . . . The functional uses of plants are one of the most objective and easily classifiable bits of information about them. (Robinette, 1970, p. 15)

He also draws attention to the fact that plants, though ignored are always there.

Plant materials have not changed, except for the introduction of some exotic variations, throughout man's history. Everything around them has changed, however, and this creates ambivalence and strains (Robinette, 1970).

Plants can and should be used to solve functional problems. As Robinette says:

> The functions of plants should be the basis for their use in environmental design. The primary aim of planting design should be to use plants in solving environmental problems. Basic to this is a knowledge of their characteristics, what functional problems they solve, and how effectively they solve them. (Robinette, 1973, p. 6)

Architectural uses of PM

Since any plant has bulk and occupies space, a plant or group of plants can be used for the same purpose that an architect uses wood, concrete, brick, and metal--to block views. Sometimes plants are used only as partial screens --more like filters--as mentioned in the JJ&R study. In other cases they can be used to direct viewing.

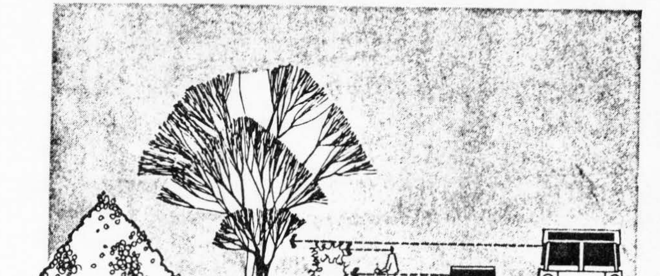


Figure 22. Screening objectionable views. (Robinette, 1971, p. 45)

Plants, used individually or in groups, have the potential of forming walls, canopies, or floors of different heights, widths, and densities. Thus plants can be used architecturally, in the following ways:

1. Screening objectionable views. Planting to screen objectionable views gives an individual freedom of movement through the environment, while sparing him an ugly view. The effectiveness of this technique varies with the age, spacing, and condition of the plantings (Robinette, 1971).

Recognizing that plants can be used in much the same way as other architectural elements opens up entirely new opportunities for landscape architects.

2. Space articulation. Plant material articulate and define exterior space singly, together with other plants, together with architecture or together with landforms.

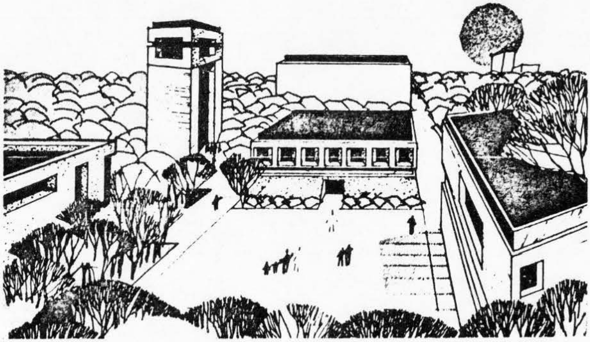


Figure 23. Space articulation. (Robinette, 1971, p. 45)

3. Privacy control. Privacy control planting alters the degree of privacy, and gives others freedom of movement through the landscape while protecting the individual from indiscriminate viewing (Robinette, 1971).

For centuries, plants have been used for privacy control. In addition to using plants as screens to block unpleasant views, a landscape architect can use them to define a given space, perceive a power plant as a structural whole, articulate a given part of an industrial complex, or reinforce the design of structures.

Engineering uses of PM

Civil engineers and soil scientists are very conscious of plants as useful components for controlling wind and water caused erosion.

In a manufactured environment, the engineer is primarily concerned with glare, traffic, sound, and soil erosion control, and with air conditioning. Plants used for such control are serving engineering functions, some of which are:

1. Acoustical control. Plants help in the screening of sounds, although they are not absolutely effective. The soft and flexible leaves, twigs, and branches absorb sound or act as oscillators. The thicker trunks and branches deflect sound and act as non-resonant scatters. By themselves, plants reduce noise from 7-10 dB per 100 feet of depth. Planting width to control sound should be at least 25-35 feet and should consist primarily of conifers for year-round effectiveness. The lowest plants should be placed nearest the

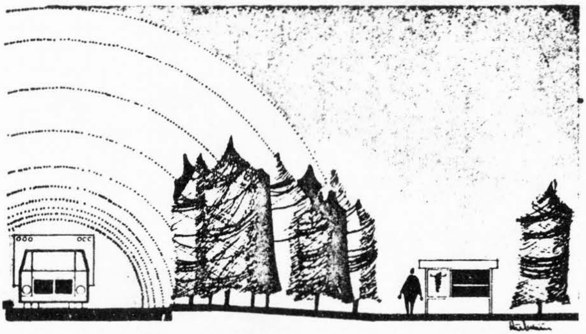


Figure 24. Acoustical control.

source of noise, as sound is windborn. Thus the noise and wind are pushed upward. Leaves, seed pods, and branches of smaller plants also mask noise, as do the sounds made by birds and animals inhabiting the plants (Robinette, 1971).

But even as the engineers, landscape architects need to be aware that plants lend themselves to acoustical control. Properties of sounds can be changed, certain noises deadened, and psychological effects can be manipulated. Plants can also prove valuable for traffic control--to separate traffic lanes, relieve monotony by sensitive placement, and protect travelers from some types of accidents. On this point JJ&R (1969) and Robinette (1971-73) differ on emphasis. JJ&R (1969) says plants generally do not make good enough absorbers; Robinette implies that generally they do.

2. Atmospheric purification. Plants purify the air by absorbing carbon dioxide, which human beings and animals exhale, and by giving off oxygen,

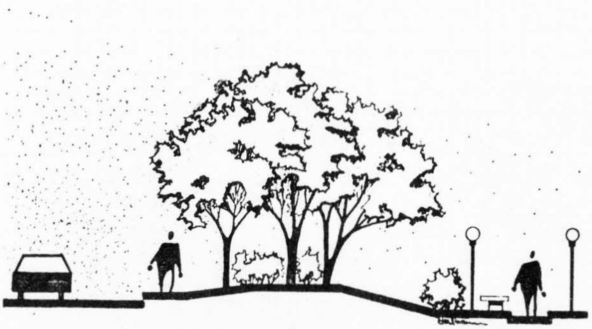


Figure 25. Atmospheric purification. (Robinette, 1971, p. 47)

which is vital to man's survival. A forest absorbs approximately 12 tons of carbon dioxide and produces four tons of oxygen per acre per year. A beech tree 8 feet tall absorbs the carbon dioxide output of 800 single family homes annually. One mature tree with a crown volume of 2,750 cubic yards must be replaced by 2,750 smaller trees each with a crown volume of one cubic yard, to have the same environment (Robinette, 1971).

3. Glare and reflection reduction. Most building materials are polished and highly reflective, and therefore accentuate natural light to the point of discomfort. At night the discomfort is continued through street lights, safety lights, advertising signs and automobile headlights. Plant materials can screen, blunt, and soften excessive glare (Robinette, 1971). In addition

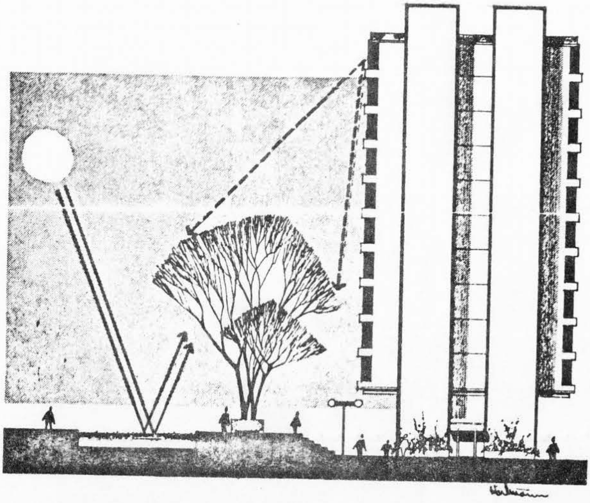


Figure 26. Glare and reflection reduction. (Robinette, 1971, p. 47)

plantings can reduce primary glare, reflection, and soften appearances of structural segments.

Climate control uses of PM

Robinette also notes that:

> The uses of plants for climate control are proverbial. Shade trees, windbreak trees, and snow fence plantings are examples. The mention of functional uses of plants ordinarily causes most people to think of climate control. To ascertain the degree to which the micro-climate may be altered by the discrete placement of the correct plant materials, extensive quantitative studies are necessary--and in many cases have been accomplished. It is generally well known that plants may be used to alter adverse

> microclimates making the environment more pleasant and livable for man. (Robinette, 1970, p. 15)

Plant materials control the climate in at least two basic ways:

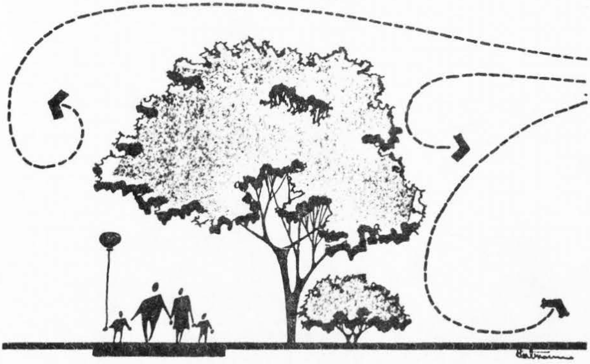
1. Wind. Plants help control wind in the following ways: obstruction, filtration, guidance, and deflection. As a rule a windbreak will reduce the wind velocity by 50 percent, 10 to 20 times the height of the planting. A block of planting with a rough surface is a particularly effective form. However, wind speed at openings and edges of plantings will be greater than open field velocity. A dense screen of trees may cut the velocity from 15 to 20 percent of open field velocity, while a loose barrier may only cut the velocity to 60 percent of open field velocity (Robinette, 1971). (See Figures 27A and 27B, p. 59.)

2. Precipitation and humidity. Plants intercept fog, dew, frost, rain, snow, sleet, and hail, and thus control the micro-climate beneath them. For instance, only 60 percent of the rain falling upon a pine forest will reach the ground. Plants also control drifting snow and retard melting by their shade. Snow distribution may be controlled, therefore, depending upon placement of plants in relation to snowfall and wind (Robinette, 1971). (See Figure 28, p. 60.)

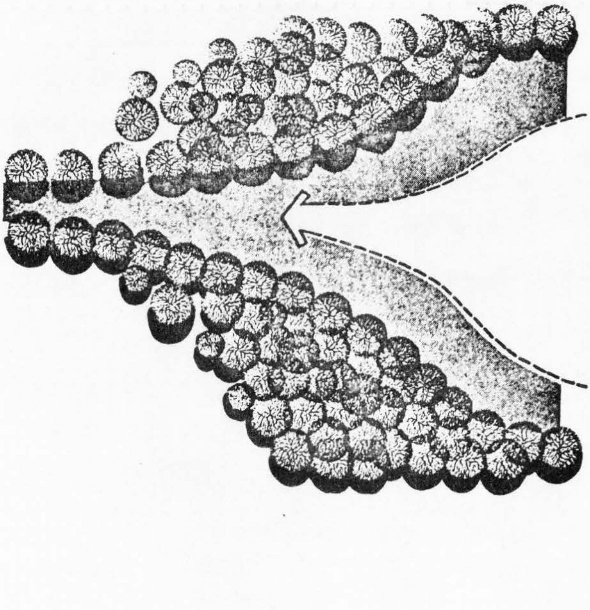
Each one of the aforementioned qualities are such that the alert landscape architect can use them in modifying the industrial scene.

Aesthetic uses of PM

> The aesthetic uses of plant material are generally the prime factor determining their usage. Most persons do not consider this a functional use. (Robinette, 1970, p. 16)



A



B

Figure 27. Wind control. (Robinette, 1971, p. 46)

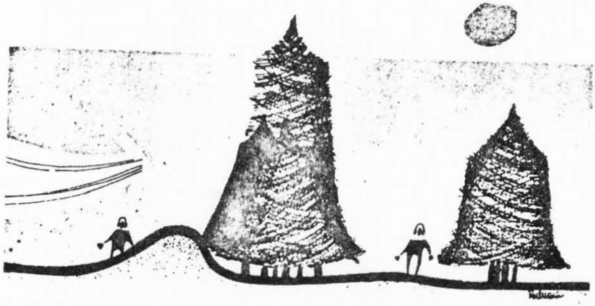


Figure 28. Precipitation and humidity. (Robinette, 1971, p. 46)

Some of the aesthetic values of plants are listed below: visual, two-dimensional elements, three-dimensional objects, complementors, attractors, unifiers, emphasizers, diverters, softener, acknowledgers, decorators, articulators, indicators, modulators, symbol-surrogate, evocators, intangibles made tangible, mood delineators, sound, odor, touch (Robinette, 1973).

Space defined.

> Human perception of space is based primarily upon sight. The relative appearance of distance from a viewer to any element which blocks or filters his view begins to create spatial sensations of enclosure. The closer the element, the more intense the spatial sensation becomes. The intensity of spatial sensations is also heightened by the appearance of discernible texture and shades of color on the element. Coarse textures and darker shades appear to advance toward the viewer, while finer textures and light shades appear to retreat. (Robinette, 1973, p. 17)

Most important. Because plants can control both the size and quality of exterior space, they can control, to a large extent, human perception of the space designed. Plants then articulate space by themselves, with other plants, in conjunction with landforms, in conjunction with buildings, and in conjunction with architectural landscape features such as walls, fences, canopies, and paving (Robinette, 1973).

As is obvious the key word in almost all of Robinette's writing is space. Space and how it applies to or affects the POZ is the key to solving the visual problems at Huntington. However, Robinette does not recognize the scale of the space involved in industrial site development. This is because his writing is directed toward urban and suburban development and the space perceived at the POZ at one given time is relatively small in comparison.

However, there is much to be learned from Robinette's writing and all of his criteria are applicable to industrial site development when understood in the correct context.

Summary

Sylvia Crowe

Sylvia Crowe stresses the need for a new tradition of design which takes into account the new mammoth industrial structures and attempts to harmonize them with the existing landscape environment. Her main concepts are that of scale (Human Scale versus Elemental or Cosmic Scale), shape, and landscape rhythm. She stresses that these art principles can be applied to solve some of the problems of the new industrial development. She stresses that science, too, must be involved to solve some of the problems such as noise level, mental strain level, visual pollution, and offensive smells.

The need for a new tradition of design for mammoth industrial complexes and structures supports objective 1, supports objective 2, and supports objective 3c.

Crowe's concept or concern of scale, shape, and landscape rhythm supports objective 3d.

These objectives together correspond and agree with the need for science and art to be brought together, analyzed, and applied in a combined and coordinated attack on our industrial environmental problems.

Lawrence Halprin

Lawrence Halprin supports the need to determine an appropriate approach or concept to attack the industrial visual pollution problem. He recommends the wholistic approach, or master plan encompassing and analyzing all elements and factors of the site.

Halprin's study supports almost all of the objectives of this thesis. Halprin feels that the goal of a landscape architect, as he forms his design criteria, is to integrate industrial forms into the landscape. This especially supports objective 1. He advocates a new wholistic approach; this supports objective 2. In the definition of wholistic, Halprin covers: (a) ecologic factors; (b) biotic factors; (c) topographical assets; (d) utilize resources of the site; (e) define separate factors and functions, industrial, recreation, and natural. These support objective 3. objective 3a, and objective 3a.

Halprin expresses his wish for the use of this study as a guideline for other industrial development. This statement supports objective 4.

Finally, Halprin points out the overall development approach = ecological, involving total environment and interaction of components (natural and man-madė) of the landscape. While this embraces practically all of the objectives, it specifically supports objective 3b, 3e, and objective 4.

Incorporated in the Halprin review and related to it are several letters representative of the 100 or so letters written during the process of this thesis development.

Mr. Williams (1972) of South Carolina Electric and Gas Company points out that while he is "cognizant of the necessity to maintain empathy with the ecology . . . [he does not] believe that there is any published criteria as to procedure."

This statement is in support of objective 1, and consequently all other objectives.

Johnson, Johnson, and Roy

The JJ&R study is based upon the concept of the POZ (Primary Observation Zone). This is the first point in the JJ&R concept. POZ provides a very excellent and valid way of approaching the design problems of the electric power plant. From somewhere outside the perimeter of the power plant site is generally where aesthetics or visual pollution is judged.

The second point in the JJ&R study is that of screening, in context with the concept of the POZ. Understanding this screening concept is the key to visual and aesthetic problems of industrial structures.

Concepts of human scale versus environmental or cosmic scale, texture, and plant form are central to the JJ&R study and concern with plant material.

The third point in the JJ&R concept is that of planting zones. These are the zones in which plant material is most effective in screening industrial structures from view at the POZ.

The fourth point: The JJ&R concern with topography rests squarely on the importance of awareness and study of the site and the immediate surroundings, in order to identify prevailing landform. Within this main concept, JJ&R stresses awareness of horizontal setback from the POZ, impact of background on the POZ, land form within the site. The goal is to blend the site with the surrounding environment. They further stress the careful evaluation of land forms in combination with plant material.

The main emphasis of the whole study remains on visual screening and how to tie in the structures to the surrounding environment.

The JJ&R study implies agreement with all of the major objectives of this thesis. But it specifically reinforces the following: Objective 2 and also 1, 3, 3a, 3b, and 4.

The main emphasis of the whole JJ&R study remains on visual screening and how to tie in the structures to the surrounding environment. This statement partially directly and partially indirectly supports objective 3e.

Gary O. Robinette

The thrust of Robinette's argument and data is the importance of plant material as functional components of design. The most important concept to grasp from the Robinette study is that: (a) plant material is a very important functional component of design; (b) that the functions can be identified, quantified, given a relative value, and (c) that the functions can be broken down into:

1) architectural functions

2) engineering functions

3) climatological functions

4) aesthetic functions

It is quite obvious that this statement emphatically supports objective 3b. Also it supports objective 3 and objective 4.

CHAPTER III

DESIGN INFLUENCE OF PHYSIOGRAPHY

Introduction

In Chapter III there are three major areas of concern, or components of physiography which have an important influence on design criteria and site development of steam electric power plants. They are:

1. landform (topography
2. climate
3. plant material

The overall purpose of the analysis in this chapter is: first to select data, and second to develop design criteria. These physiographic factors will be scrutinized to discover the relationships among the three factors, and they will be discussed as they act upon one another.

Climate and topography will be discussed in two categories. The first category is: The greater or cosmic scale, the influence of major topographical features, the influence of major climatological factors as cosmic scale elements, and how these two factors influence plant material.

The second category is: The lesser topographical features and micro climate factors as they relate to small scale (human scale) or the immediate environment and individual plant material.

As Toth (1971) emphasizes, this data is being selected and analyzed for the purpose of making decisions about design and utilization of the landscape, and because the writer feels they are of major importance in their influence on site development. The physiographic factors will be analyzed to determine and understand their nature, proportion, function, and relationships.

The focus of this analysis is to set the stage and establish background (what and hows) of topography, climatology, and plant material for: (1) establishing site development design criteria, (2) for the understanding and analysis of site data that will be discussed in Chapter IV, and (3) to set the basic criteria for the critique of Huntington Canyon Power Plant.

Design Components

Cosmic scale factors that man cannot change/influence

There are cosmic scale natural landscape forms, features, and forces that inevitably influence industrial site design. Such physiographical elements can be altered little, if at all. They must be accepted as they are, and planners must adapt to them. These unalterable elements consist of mountain ranges, river valleys, coastal plains, soil types, lakes, oceans, and other dominant topographical components. Major features such as precipitation, frost, fog, water tables, and seasonal temperatures, must be considered. Climatological forces such as winds, tides, sea and air currents, erosion, the process of growth, solar radiation, lightning, and gravity also cannot be changed for the convenience of environmental engineers.

Instead, as Simonds (1961) points out, landscape architects and engineers can only analyze these overwhelming cosmic scale landscape elements to determine their potential effect and then shape their plans accordingly. If such professionals are environmentally aware, their plans will harmonize with these major cosmic scale landscape elements. Such considerations are fundamental to all planning projects and construction activities.

Human or micro scale factors that man can change/influence

Other topographical elements that engineers and planners can modify or manipulate are hills, woods, streams, swamps, lakes, ponds, etc.

Influence of man on minor (human scale) topo. Simonds (1961) goes on to say that in any modification attempt, there are four general courses of action--preservation of the natural form; destruction of the natural form; alteration of the natural form; and accentuation of the natural form.

Simonds (1961), gives an example of each of these actions as applied to a hill:

1. Preservation of the natural form. Through analysis, it may be found that the best choice is to preserve the site in its original state. This hill may be a ski slope, a ranch, or community focal point. It may be found that left undisturbed, it will and does produce some benefit: aesthetic, financial, recreation, etc. The precedent has been set in the U.S. by the National Park system, and in some lucky cities (Philadelphia) through their inter-park system.

Figure 29. Preservation of the natural form. (Simonds, 1961, p. 29)

2. Destruction of natural form. Analysis may dictate that the hill be entirely destroyed or bulldozed, perhaps for a parking lot, a highway, or a lake. In this case the original landscape character is negated as a design factor.

Figure 30. Destruction of natural form. (Simonds, 1961, p. 30)

3. Alteration of natural form. Analysis may dictate a complete alteration of the original landscape character through grading, terracing, removal of natural cover, or other development. This may result in site improvement as seen in the beautiful terraced hills around Beppu, Japan, rice paddies laced with small pools and canals, or a site despoiled, denuded, eroded, or mined-out.

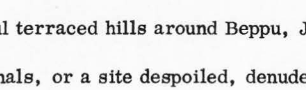


Figure 31. Alteration of natural form. (Simonds, 1961, p. 30)

4. Accentuation of natural form. The result desired may be to accentuate the essence of the landscape character. A mediocre hill can be made to appear bold, majestic, rugged, and mountainous.

Figure 32. Accentuation of natural form. (Simonds, 1961, p. 30)

Tremendous influence of topography (landform)

Of all the environmental elements, landform is the most important to landscape architects and power plant engineers.

Influence of TOPO on human activity. Landforms are the distinctive configurations of the surface and exert tremendous influence on human activity patterns.

> A mountain chain is an effective barrier between groups of people who live in adjacent lowlands. A plain, on the other hand, may be densely populated, rich in agricultural resources, and unified culturally and politically by a network of good roads and railroads that permit people with common interests to intercommunicate freely. One coast line, deeply indented with excellent natural harbors but bordered by a rocky rugged coastal belt, may produce a community of seafaring humans, adapted to fishing, ocean commerce, and shipbuilding. Another coast line, whose simple plan and shallow bottom provide not a single good natural harbor, may be bordered by a low, fertile coastal plain. Here human activity turns naturally to agriculture. (Strahler, 1968, p. 361)

Influence of TOPO on industrial sites. The impact of landform on industrial design (in this case power plants) is illustrated by the drawings that follow. Landform, either natural or man-made, has scale. The effect of large or cosmic scale landform is shown in figures 34 and 36. With foothills or mountains as a background, the power plant or substation does not overwhelm the viewer and hence becomes a blended and positive part of the overall landscape.

The other drawn examples show different ways that manmade landforms such as berms, swales, slopes, sunken pads, etc., can be used to influence power plant design. Of these, berms and pads are the easiest to construct.

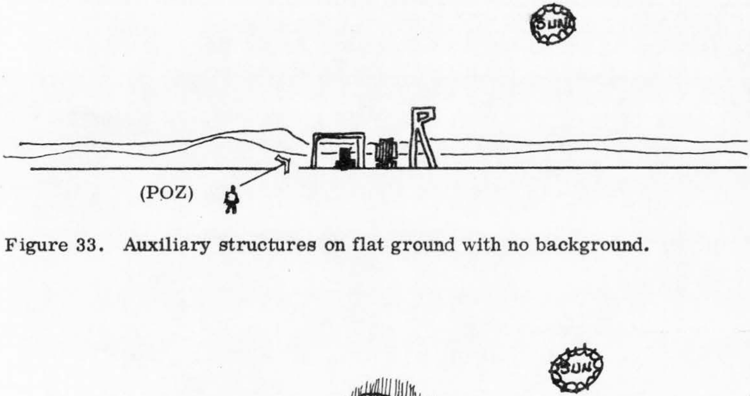


Figure 33. Auxiliary structures on flat ground with no background.

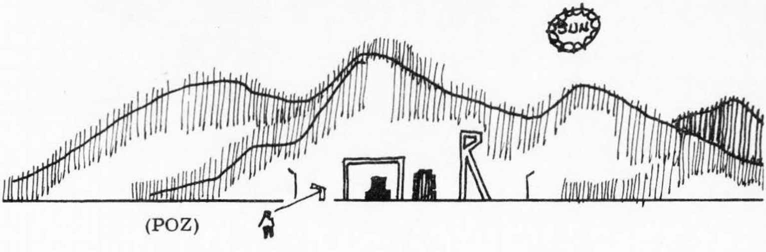


Figure 34. Auxiliary with rolling foothills as background.

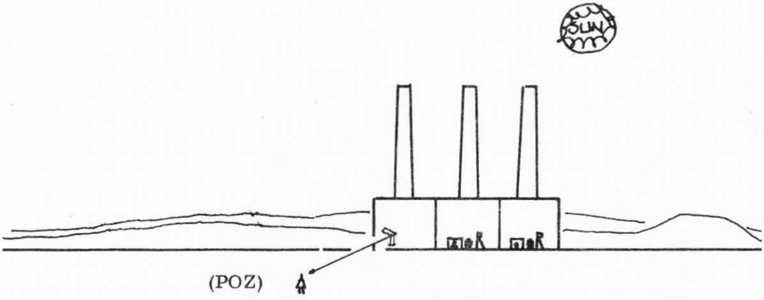


Figure 35. Power plant on flat ground with no background.

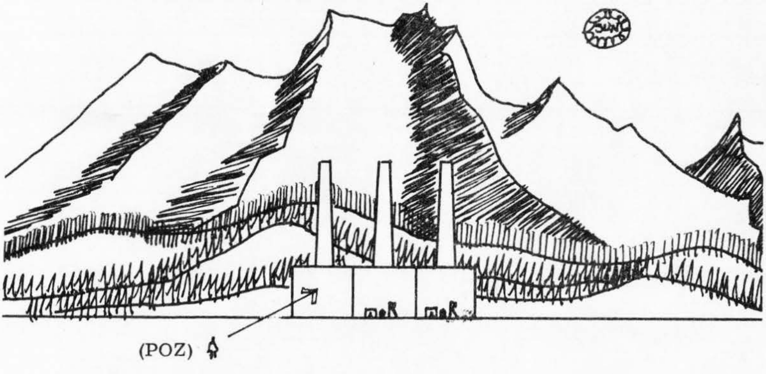


Figure 36. Power plant with mountainous landform as backdrop treatment of auxiliary structures.

Figure 37. Dike or berm screen.

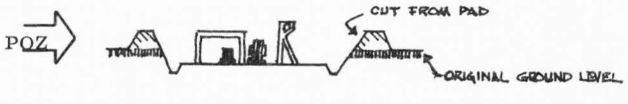


Figure 38. Sunken pad with berm screen.

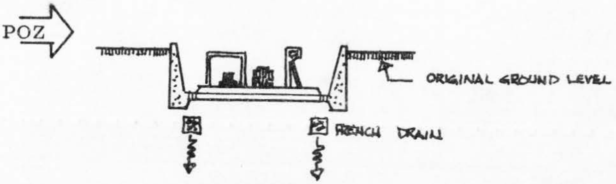


Figure 39. Sunken auxiliary.

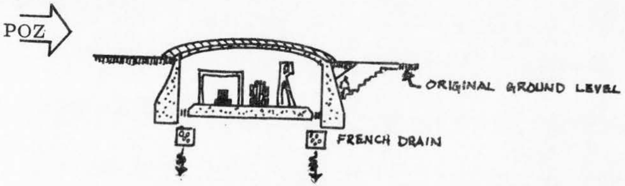


Figure 40. Underground auxiliary.

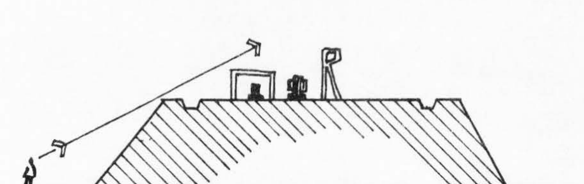


Figure 41. Raised pad of various elevations.

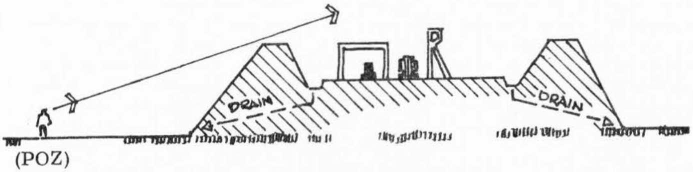


Figure 42. Raised pad with berm or dike.

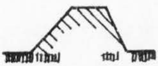


Figure 43A. Dike w/45° slope.

Figure 43B. Berm/more gentle slope.

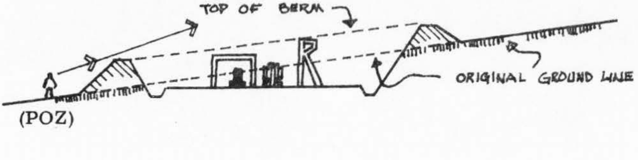


Figure 44. Gentle slope/auxiliary structures screen.

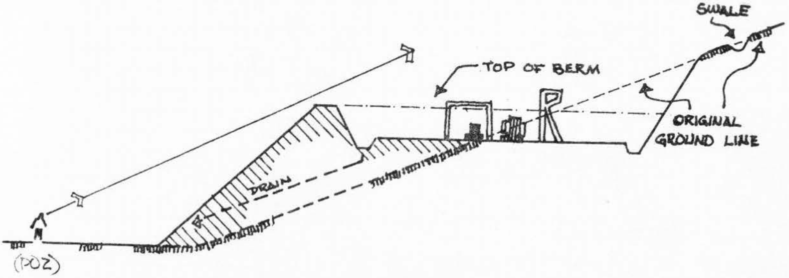


Figure 45. Steep slope/auxiliary structures screened.

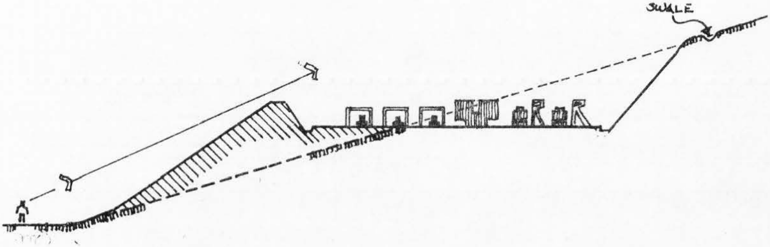


Figure 46. Multi auxiliary layout: Example (Mechanical draft cooling towers).

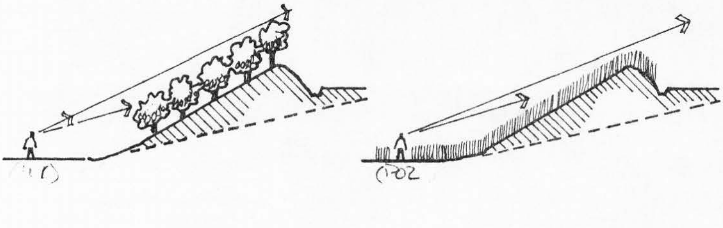


Figure 47. A. Add plant material to heighten berm. B. Ground cover to heighten and soften berm: tall grasses: Example--Sorghum.

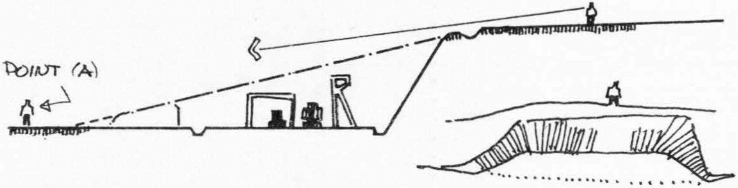


Figure 48A. Cut into bank surrounds auxiliary, screens from three sides, fourth side can be screened by plant material.

B. View from Point A

Influence of soil on PM. A component of landform that is of major concern is the type of soil that lies beneath the surface.

> Size of soil particles (soil texture) and shape of particles, which determines how they fit together (soil structure), may vary markedly within short distances. . . .
>
> These variables are a product of the manner in which the soil originated and the time involved in its development. Great areas of the earth are covered with soils that overlie the parent rock from which they were formed. These are sedentary soils, whose materials are termed residual, if of mineral origin, or cumulose, when deposited as organic matter. If soil material has been brought to its present location by some agency such as wind, water, gravity, or ice, it is said to be transported and will have certain distinguishing characteristics. (Oosting, 1956, pp. 163-164)

Soils are usually found in three generally recognized profiles: A horizon, B horizon, and C horizon. Each layer or horizon has its own texture and structure characteristics. These in turn have definite effects on the type of plant cover that grows in them through their influence on air and water permeability. In addition, organic materials that may be present in the soil (usually the A horizon) modifies the soil structure and furnishes plant nutrients that may not be available from mineral sources.

Newly-formed soil bears no resemblance to mature soil of the region. It cannot support the plant life that grows on the mature soil, but the plants that are able to grow on it contribute to its development, primarily through their decomposition products. Over a period of time, therefore, the soil changes allow new plants to grow, and thus plant and soil changes parallel each other. Soil development and vegetational development are intimately related and together are controlled by climate (Oosting, 1956).

Other physiographic influences on PM. Topography, or lay of the land, also exerts influence on plant type, drainage, erosion, solar radiation, micro-climate, and a number of other factors.

1. Influence of TOPO variation on PM

Oosting (1956) points out that topography affects plant material. Topography modifies other factors of the environment, thus indirectly affecting plant material. Topography influences all plant communities. If topography is uniformly level, all other factors being equal, plant material is uniform.

Normal topography is not uniform. Slopes, bluffs, and ridges of various exposures, lowlands, drainage lines, and depressions are commonly found forms of topography.

Irregularities in topography result in light, temperature, and moisture conditions, varying greatly between north and south slopes or ridges and depressions.

Plant material on slopes is the direct result of interaction of light, temperature, and moisture variations. In the northern hemisphere, as here in Utah, south-facing slopes receive more light, higher temperatures, and therefore retain less moisture than the average site, while north-facing slopes receive less light, are cooler and moister than the average. Differences vary with degree and extent of slope, but, generally, north and south slopes differ enough to support distinctive vegetative types.

2. Influence of erosion on PM

Geologic erosion is normal and universal. Normal erosion produces good topsoil and subsoil. Accelerated erosion is topsoil eroding faster than it is building up. On a mountain slope for example, topsoil is very thin. In a hollow, however, topsoil is deeper and is geologically building at a rapid rate (Oosting, 1956).

3. Influence of water movement on PM

It is obvious that water moves toward depressions. Therefore depressions are moister (wetter) than uplands and usually support distinctive vegetation. Depressions are wetter; uplands are drier. Immature topography has poor drainage and therefore is covered by lakes, ponds, and bogs. Mature topography has better drainage because depressions are inter-connected by streams. However, flood plains along stream banks have more favorable moisture conditions than the uplands and therefore support distinctive vegetation. As evidenced by the willow leaf cottonwoods along Huntington Creek (Oosting, 1956).

4. Influence of moisture on PM

Abundance or deficiency of water has the greatest influence on plant material differences associated with local topography variations. Water deficiency is likely to produce/be associated with plant material with absorption or restricted transpiration characteristics.

Water excess can create a region where slope and exposure produces scarcely noticeable differences in vegetation; this situation can only occur, however, under conditions consisting of a combination of fog, clouds, or rain maintaining a humid atmosphere, low transpiration rates, and a plentiful water supply (Oosting, 1956).

5. Influence of precipitation on PM

There are topographic effects of a regional nature, in addition to local topographic effects, associated with mountains.

Any increase in altitude is accompanied by a decrease in temperature and is generally accompanied by an increase in precipitation and results in vegetational zonation. Within each zone, the aforementioned local effects of topography clearly produce zonal variations. Zones on a south slope occur at higher altitudes than on a north slope, and the species of a particular zone will be found extending downward in ravines and upward on ridges (Oosting, 1956).

6. Influence of mountains (landform) on PM

Mountains affect growth conditions; they provide moisture for low lands. Some are centers for rain cloud formations. Mountain streams fed by precipitation flow to the valleys and plains.

Other mountains lying at right angles to prevailing winds act as barriers. Moisture falling on these mountains leaves little for areas beyond. This explains the lack of moisture in the Great Basin. Pacific prevailing winds drop their moisture over Coast Ranges and the Sierra Nevada (Oosting, 1956).

All of these factors are acting on Huntington because Huntington is located at the foot of a plateau range and on the edge of a desert in the Great Basin.

Basic Landscape Architecture Principles

Influence of natural, cultural, and aesthetic factors

Since natural, cultural, and aesthetic factors affect final site selection of any industrial plant, planning guidelines should be established to facilitate later development.

Natural features and the spatial pattern of views, spaces, and sequences are classed as aesthetic factors in Rubenstein's 1969 book, A Guide to Site and Environmental Planning.

A listing of natural factors that influence site selection should include: landforms, topography, hydrology, soil types, vegetation types, wildlife, and climatic factors (solar orientation, seasonal winds, precipitation, and humidity).

Some cultural factors are: existing land use (adjacent property and off-site nuisance), linkages, traffic patterns, density and floor area ratio, utilities, existing buildings and historic buildings and landmarks.

Obtaining maps. Those responsible for selecting power plant sites must ask themselves questions and find suitable answers before construction can begin. The first move should be to obtain topographic maps of the target area. These maps, available from the U. S. Geological Survey, show locations and elevations of natural as well as man-made features, relief, and vegetation.

Data necessary for landscape site development, selection, and analysis. Rubenstein (1969) goes on to say that with the help of and reference to these maps, the following data should be gathered, compiled, and analyzed:

1. The geologic processes affecting the site; the depth at which rock is found; the type and depth of rock present. Test borings of rock taken at various locations will help determine its adequacy as a base for the foundation of buildings.

2. A slope analysis will aid in recognizing which areas of the site should be used for building locations, roads, or parking lots, and which are not feasible for building at all, because of steep grades.

3. The drainage pattern of the land must also be thoroughly investigated, so that the site drainage may make use of existing watershed drainage patterns. This includes both surface and subsurface drainage.

4. The depth of water table is particularly important as if it is too close to the surface there will be extra costs for waterproofing and pumping, and if it is too low, water supply may be a problem.

5. The site planner can also make use of existing vegetation, preserving large trees, instead of later being forced to buy small ones. On a heavily wooded site, trees may be carefully thinned to open potential vistas.

6. The vegetation of the area should be studied to determine which plants are native and which should be introduced for wind protection, shade, buffer zones, screens, or backdrop. A soil analysis will also show which if any nutrients should be added to improve plant growth.

7. Climatic factors must also be considered as they affect the site. Such data is available for most areas from the U. S. Weather Bureau, and includes temperature, precipitation, wind, humidity, and amount of sunshine. The

elevation of the site is important, as the temperature drops approximately 1^{o} F in summer for each 300 foot rise in height from the earth's surface.

8. The two major factors affecting vegetation are precipitation and temperature. Vegetation can be used to block winds, or it can be thinned to allow sunlight through. Deciduous trees provide shade in summer.

9. Water bodies also affect the climate of the site by moderating the temperature. In winter they retain heat, and in summer they are cool. Their influence naturally decreases with distance inland.

10. There are generally four types of climates: cool, temperate, hot arid, and hot humid. In each of these the site planner needs to take into consideration solar orientation for buildings and topography, for the best use of air flow.

Figures 49 to 52 illustrate factors for each climatic zone; structures are placed to receive the best solar orientation for each climatic region (Rubenstein, 1969).

Influence of on-site materials. Last but not least is considering the use of other on-site materials. For example, rock is a prominent element in design because of its symbolic, structural, and aesthetic qualities. It may be used as a natural feature or a sculptural element, especially in the semi arid West.

> Rock that is indigenous to a site can be used to great advantage in its natural state as outcrops, ledges, or boulders as well as in walls, sculptures, podia, or buildings themselves. Taking the naturalistic approach, if the stone is used for both a structure and other site elements the building may become unified with the site through proper handling. On the other hand, the man-made approach can be emphasized

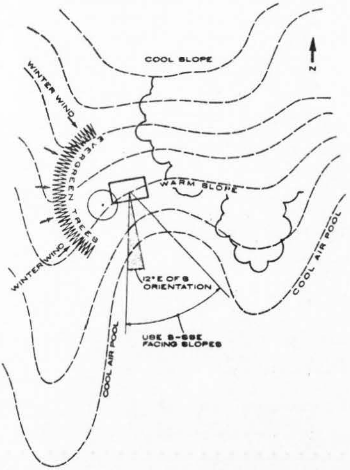


FIG. 2-8. Cool climates.

Figure 49A. Cool climates. (Rubenstein, 1969, p. 18)

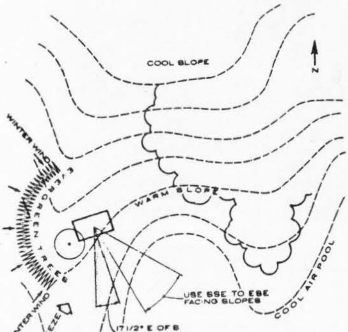


FIG. 2-

Figure 49B. Temperate climates. (Rubenstein, 1969, p. 19)

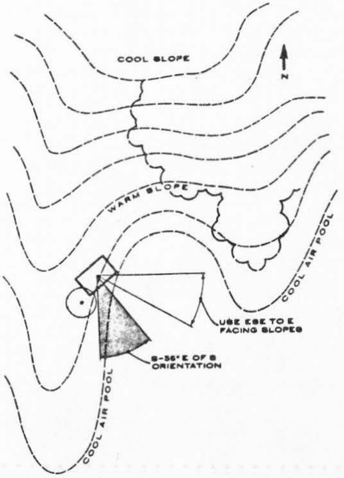


FIG. 2-10. Hot arid climates.

Figure 49C. Hot arid climates. (Rubenstein, 1969, p. 20)

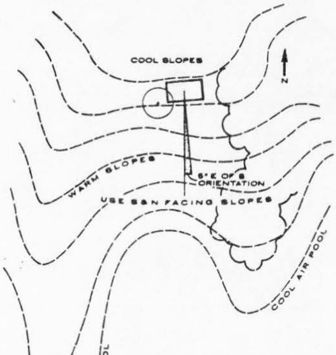


FIG. 2-

Figure 49D. Hot humid climates. (Rubenstein, 1969, p. 21)

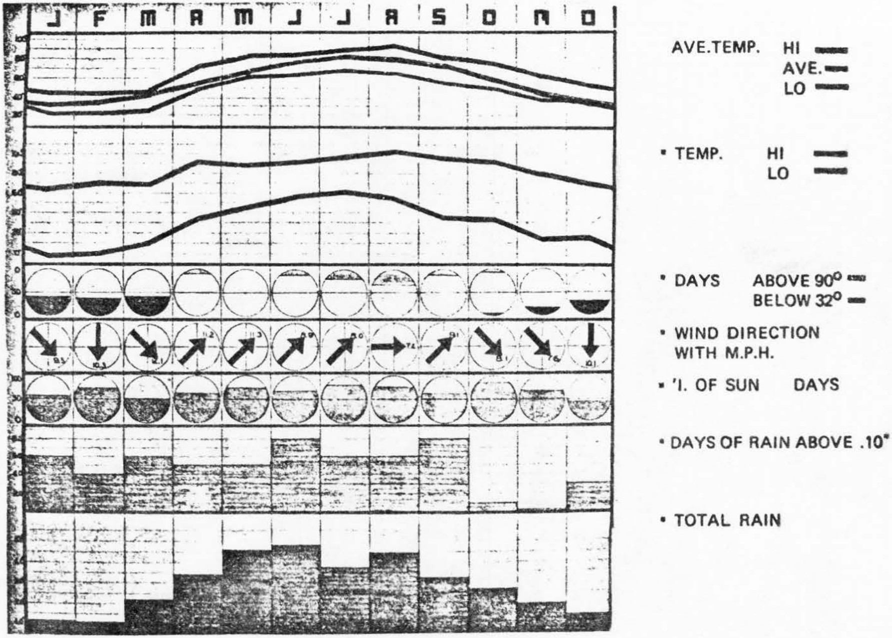


Figure 50. An example of graphically illustrating climate data. (Rubenstein, 1969, p. 22)

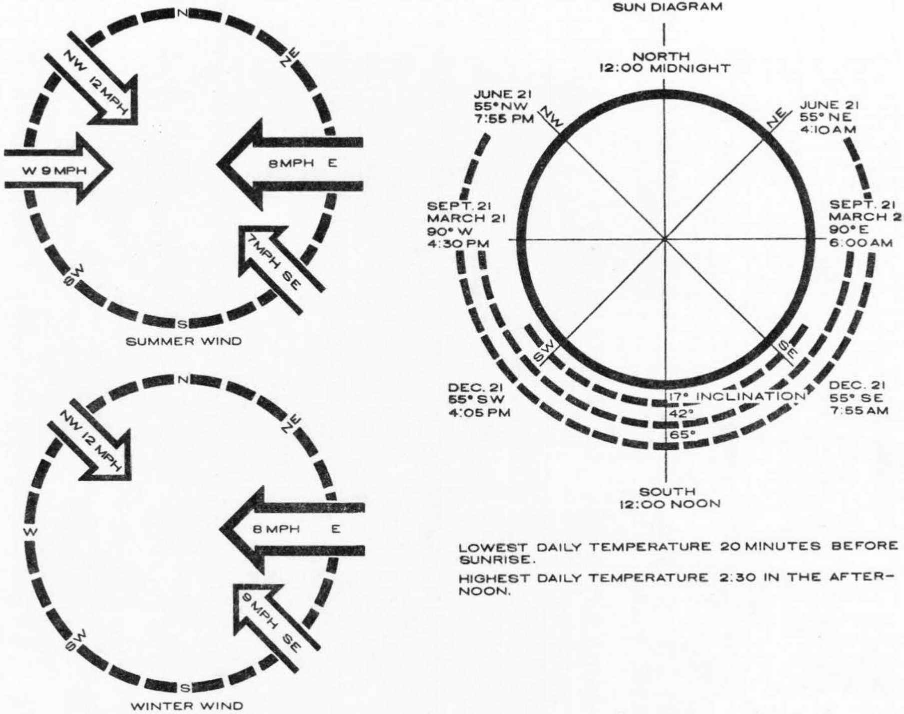


Figure 51. Graphic illustrations of wind and temperature data. (Rubenstein, 1969, p. 23)

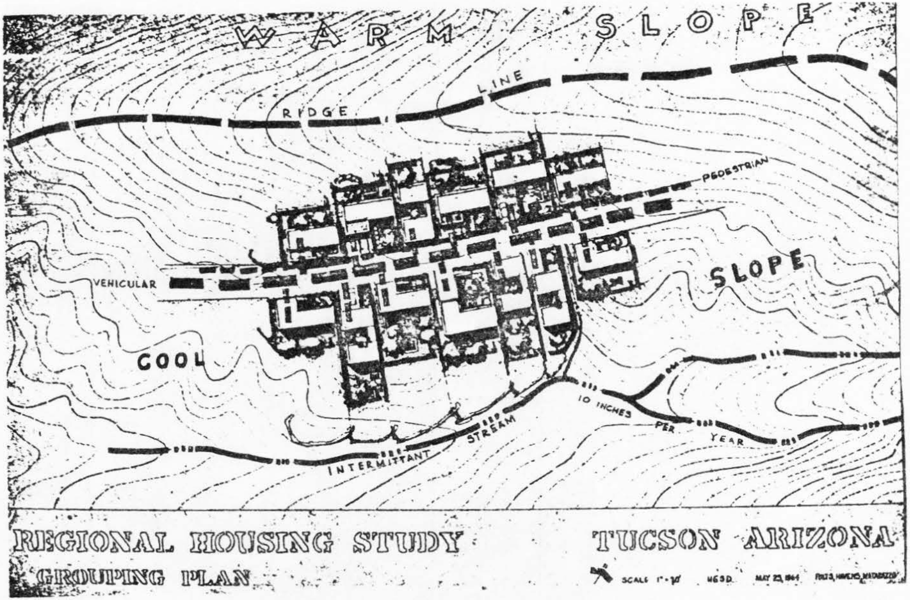


Figure 52. Graphic illustration of typical hot arid siting for structures in zones such as Huntington. (Rubenstein, 1969, p. 24)

by placing the building on a podium and having the natural landscape lead to the man-made structure. Either approach may work; it is up to planner to decide which method is appropriate on the given site.

Man-made materials such as brick or concrete created from natural elements can also be classified as rock. These are widely used in construction and detailing. (Rubenstein, 1969, pp. 73-74)

The following diagram suggests an appropriate approach for making decisions when the focus is a finished land-use or master plan.

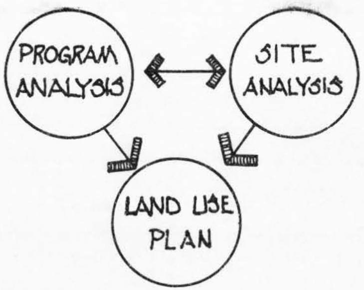


Figure 53. An approach to land use planning. (Rubenstein, 1969, p. 69)

Along with land use and circulation, visual design factors and natural elements must be studied in structuring the site plan. It should be viewed as a total organization of space formed with buildings, earth, rock, water, and plant material. It must be structured so that its parts not only work together but are visually unified and coherent as well. (Rubenstein, 1969, p. 69)

Summary

Cosmic scale factors

As Simonds (1961) points out, physiography influences site development design criteria in the following way: On the environmental or cosmic scale, design factors consist of landform, geology, and climatology. The landscape architect must accept these factors because he can do nothing or next to nothing about their effect on a region or site environment. His only option is to ignore them altogether or anlyze these overwhelming landscape elements, determine their potential effect, and then shape his plans accordingly. If he is environmentally aware, the plans will harmonize with these major cosmic scale landscape elements.

Micro/human scale factors

Micro or human scale design factors consist also of landform and climatology. But these are man-made and other small scale landforms, and micro climate. And added to this list is plant material. These elements can be manipulated by the landscape architect and used to influence the site development of electric power plants.

Topography or landform modifications. In any modification attempt there are four general courses of action: (a) preservation, (b) destruction, (c) alteration, or (d) accentuation of the natural landform. On site materials (rock, etc.) can also contribute to modification and fitting of structures to the site.

Soil modification. Soil is an obvious component of landform and has great influence upon plant material habitat. Soil type determines to a large extent the plant material that can survive on a given site.

Climatology modification. Climate can only be modified on the micro climate scale in that more water can be added (irrigation), the temperature can be raised or lowered by manipulation of other elements such as plant material, landform, or water.

Plant material modification. Plant material is the reflector or recipient of the good or bad effects of these other modification elements. Modifications by these other elements can improve or retard the habitat conditions of plant material and can also be modified to allow introduction of new species of plant material. Plant material themselves are modifiers of the aesthetic and physical environment and can improve or retard their own condition as evidenced in the progression of plants from weed to climax forest.

Tools of the landscape architect or design criteria

The goal of the modification or manipulation of all of these factors is to give the landscape architect or designer tools by which he can fit the function or industrial structures to the site environment with the least ecological and environmental damage and the most aesthetic and visual success.

This breakdown and analysis of physiographic factors obviously directly supports objective 3e as well as 3a, 3b and 4 and therefore by inference, objective 1.

CHAPTER IV

EXISTING SITE CONDITIONS

Introduction

Chapter IV will comprise a general physical description and discussion of physiographic site conditions, will include a description of the Huntington Canyon Electric Power Plant itself, a discussion of plant material and plant indicators (see Appendix A), a physical description of the topography and other geologic data, and a discussion of the flora and soil conditions and problems of Huntington itself. There will be a discussion of weather as it affects the local plant material, and the major and minor components of the Huntington plant. The chapter will close with a review of Dr. Hill's environmental impact study.

In this chapter selected data will be compiled and developed for the case study of Huntington, for the purpose of verification and testing of the objectives listed in Chapter I, and for the purpose of examining the data as it applies to site development criteria.

This data will give the solid background of information for the critique in Chapter V, and allow the reader to study the existing site conditions to draw his own conclusions from the raw data, and later to see how it relates to the critique and how it makes up the design elements for site development design criteria.

Analysis of Existing Site Conditions

General physiographic description of the Huntington region

City of Huntington and site location. The Huntington Power Plant site is located about 7 miles up Huntington Canyon to the west of the city of Huntington, Utah, just off Utah 31 (see map). Huntington is a small city of about 850 population, located approximately 22 miles to the south of Price, Utah, on Utah Route 10, in Emery County.

Relative elevations. The city of Huntington has an elevation of approximately 5,800 feet while the power plant site has an elevation of 6,450 feet, a difference of 650 feet in 7 miles. The canyon continues to the northwest for another 22 miles before it comes out above 9,000 feet.

Regional description, features and influence. This general area is called the Colorado Plateau. The upper mountains are actually High Plateaus while the valleys are actually Canyon Lands. The city of Huntington is in the lower foothills of the Wasatch Plateau close to the edge of Green River Desert, with mountains to the west and desert to the east and south. This location also marks the western boundary of the Colorado Plateau Canyon Lands, a transition area for the steep slopes of the Wasatch Plateau (Roylance, 1972).

Emery County. Emery County has unusually varied terrain, ranging from high, forested mountains on the west (Wasatch Plateau) to valley (Castle Valley) to rugged, rocky wilderness (San Rafael Swell) to desert (Green River Desert). Emery County is second in coal production (after Carbon County), possessing vast

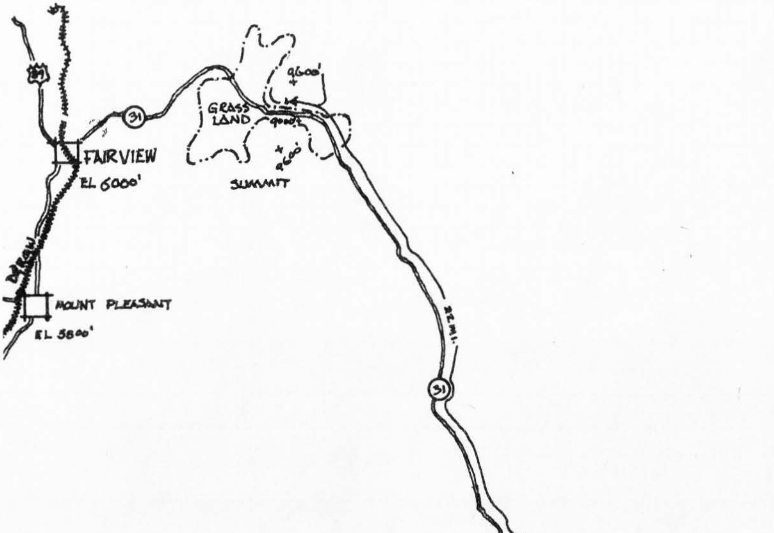


Figure 54. Orientation map of Huntington.

deposits of this mineral. It is also an important producer of uranium and natural gas. Most of the people live in Castle Valley, and Castle Dale is the county seat (Roylance, 1972).

PM general flora and variety of habitats.

> The flora of Huntington Canyon drainage is remarkably rich [see Appendix A]. There are a large number of different habitats on the plateau. The nature of the topography is such that there is great diversity, from the xeric habitats on top to about 10,000 feet with extensive stands of Picea pungens (Colorado blue spruce), to the distinctive flora of moist meadows high in the main canyon, as well as the various habitats of the desert below. (Hill, 1971, p. 69)

Power plant site and plant indicators. The actual power plant site is located just inside of the mouth of Huntington Canyon, in the upper foothills. The majority of the general site is dominated by Pinyon Pine and Juniper, about 10 to 15 feet tall on the average. However, the north edge borders on Huntington Creek. Approximately 200 feet above the water is the immediate site (the power plant, stacks, generators, boilers, coal storage, administration building, etc.), on a partially man-made bench with a 100 percent slope to the water below. The study site elevation is 6,400 feet with steep plateau slopes ascending sharply up approximately one mile on either side of the canyon center line to 8,500, 9,200 feet.

PM of Huntington Creek. The plateau tends to be covered by evergreen forest and the canyon floor has basic foothill vegetation, modified by the Huntington Creek meandering down the center of the canyon floor, creating an environment for narrow leaf cottonwood and associated plant material.

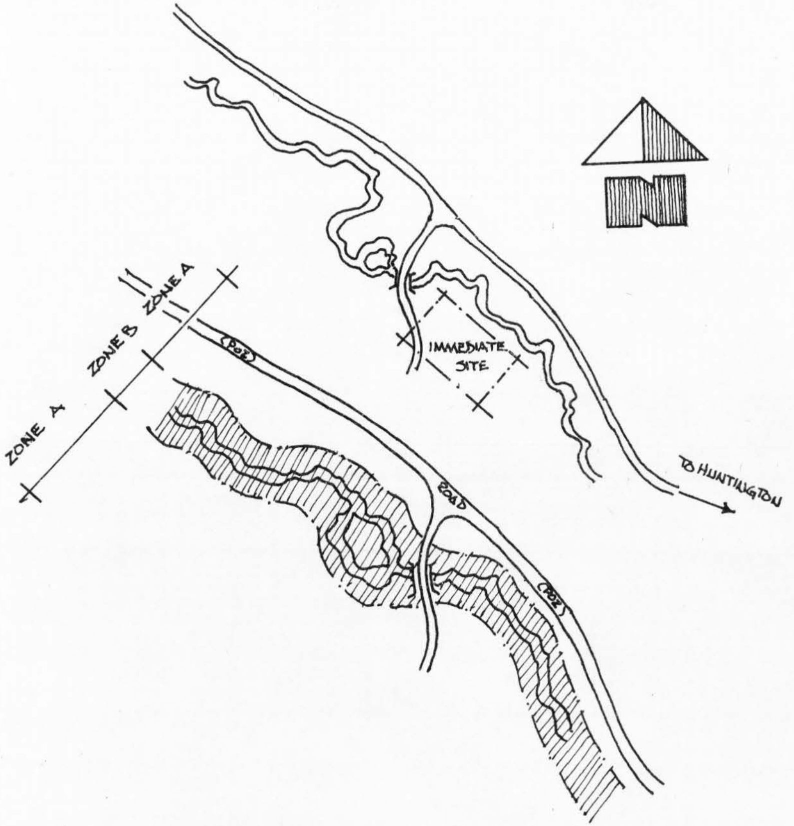


Figure 55. Zones influenced by water or lack of water. Zone A refers to the normal foothills semi-arid plant material zone; Zone B refers to the plant material zone influenced by the Huntington Creek. The principal plant indicators for Zone A are pinyon pine and Utah juniper. For Zone B it is the narrow leaf cottonwood.

The creek banks are densely covered with vegetation about 50 to 100 feet on each side of the creek. This wide strip of deciduous plant material that extends down the approximate center line of the canyon for the whole length of the study site is due to the limited change in microclimate induced by Huntington Creek which runs strongly year round.

PM limits. The mouth of Huntington Canyon forms a rough triangle that comprises a relatively fertile and productive area. (See map, Figure 56.) Plant material in this canyon is limited at its upper elevation by extreme cold temperature and at its lower elevation by lack of water. In the case of this triangle, however, the low elevation of the canyon floor protects the plant material in the area from the extreme cold of higher elevations and a relative abundance of water protects from drought.

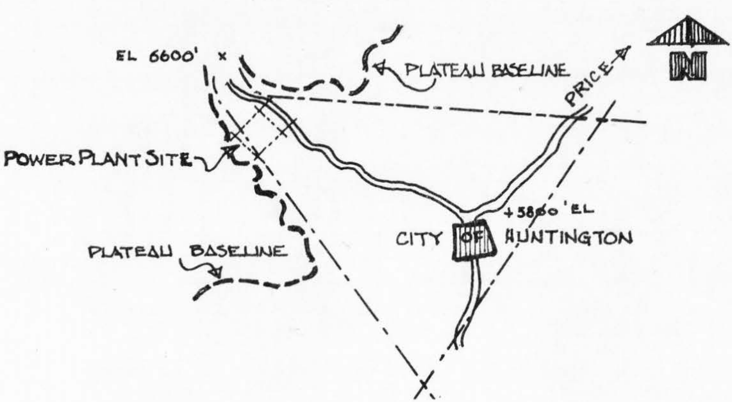


Figure 56. Rough triangle formed by canyon mouth.

Canyon sides and associated PM. The south face is steep, rising suddenly from 6,400 feet in elevation at study site location to 8,300 feet is approximately the distance of one mile (horizontal distance), forming steep cliffs. This south face is sparsely covered with vegetation, much like that on the desert to the east.

The north-facing slope, however, is more gentle although very majestic (high). It is more densely covered and relatively lush with evergreen material from the center of the canyon floor to about halfway up the base. The upper portion of the north face has some 200-percent slopes but not nearly the extent of the south face. Little plant material grows on these steep upper slopes but the plateau top is covered with relatively heavy evergreen (douglas fir and Colorado Blue Spruce) plant material.

PM and solar radiation exposure. In most any global situation there would be a differentiation between a north and south facing slope, but here in southern Utah the contrast is especially strong, aggravated by the intense summer sun striking directly on the south face; a high elevation (closer to the sun); less atmosphere to lessen the impact of the sun's rays; the lack of direct sun on the north face in winter; and the short duration of sunlight on the north face, year round. Due to the late date of the sun in spring to warm the north face and the early date of withdrawal in fall, the sun leaves the north face in total shadow for lengthy periods. The north face is cooler, holds moisture longer, and snow stays longer. As a result, the lower north face foothills have a heavier growth of evergreens, mainly pinyon-juniper type.

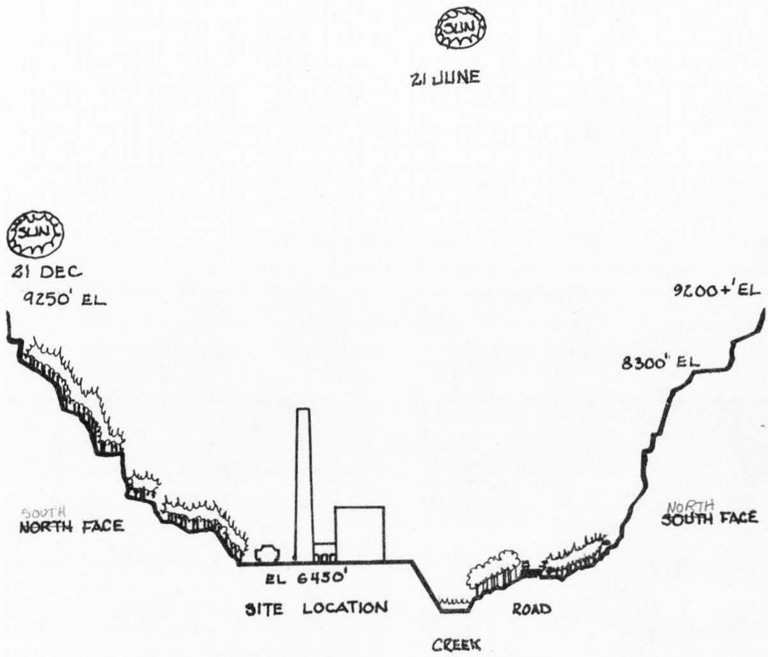


Figure 57. Cross section of canyon looking west. No scale.

PM, recreation and scenic value of region. Utah State Highway 31 wanders up the Huntington Canyon, following the creek through many wooded campsites, past the new dam site (high above it to the northeast) and on into a wide meadow grassland, elevation 9,000 feet, bordered on the north and the south by gentle mountain slopes. These slopes reach an elevation of approximately 9,600 feet on either side, covered by a dense stand of aspen to the north and an even more dense stand of fir to the south. Almost the whole length of this road (just past the power plant study site) is included in the Manti La Sal National Forest and Huntington State Park. Included are many recreation, fishing, hunting, picnic, and scenic areas. Thus the whole canyon receives a great deal of public use. Obviously in constructing this power plant, Utah Power and Light (UP&L) should be sensitive to public opinion and take great pains to integrate the structures carefully and thoughtfully into the site and surrounding scenic property.

PM reseeding and monocultures/overgrazing and erosion.

> As is generally known, severe overgrazing of the plateau caused extensive flooding, especially on the west side. Due to accelerated erosion, enough topsoil was removed from the top of the plateau to expose rock where there had been soil in many places. These areas will never recover until the soil-forming processes produce an accumulation of soil anew. Although evidence of accelerated erosion can be seen throughout the canyon, it is believed that grazing is under relatively good control today. It is thought that by more intensive management practices involving reseeding of native non-weedey species, effective plant production could be greatly increased at least in favorable places. . . . [Some type of deliberate management by man might prove profitable in the event of air pollution damages.] [Present reseeding is more or less in

> terms of monocultures, which is a dangerous practice in that no variation of adaption exists in case of factors such as an unfavorable water regime, nutrient regime, or invasion of pests.] (Hill, 1971, p. 73)

This quote by Dr. Hill concerning erosion and monocultures lays the foundation for the recommendation that: power companies become involved and concerned with plant material on a regional basis, both for their own improved public image (greater acceptance of power plant sites on the part of the public) and for the good of the local people and improvement of public and private (their own) land.

Climatological influence on PM

General climatic factors affecting PM. Plant material in any given area is dependent on either available moisture or compatible temperatures. Both these factors are related to climate. To obtain approximate climatic data for the Huntington Power Plant, records from surrounding weather stations were obtained and studied.

Climate data gathering locations. Two towns, Ferron and Hiawatha, near Huntington were selected for total precipitation (rain plus snow) and temperature data. Ferron, in Emery County, is approximately 20 miles, almost due south of the study site, in approximately the same relationship to Black Canyon, as the city of Huntington is to Huntington Canyon, Latitude North 39° 06'; Longitude West 111° 08'; at an elevation of 5,925 feet. (The city of Huntington is at 5,800 feet elevation, and the study site is at 6,400 feet elevation.) Hiawatha, in Carbon County, is eight miles north northeast of the study site and is almost exactly in the same relationship to the canyon as the Huntington Power Plant site is to the Huntington Canyon. Hiawatha is at Latitude North 39° 29'; and Longitude West 111° 01'; at an elevation of 7,230 feet.

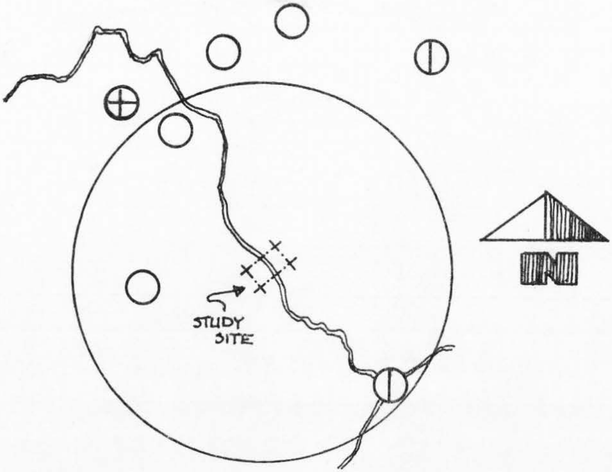


Figure 58. Location of weather stations in relation to study site.

Precipitation. Total precipitation is minimal, often less than 1 inch per month as shown in Table 1. One can see that a rise in elevation results in high precipitation rates.

Temperature and effect of altitude. Mean monthly temperatures for the two towns are shown in Table 2, as well as mean daily maximum and mean daily minimum temperatures. One can see that an increase in elevation is accompanied by a lower mean temperature.

Table 1. Total precipitation (in inches per month)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Ferron	.89	.49	.42	.41	.69	.54	.64	1.13	.68	.84	.62	.57	7.92
Hiawatha	1.00	.89	.97	.91	1.08	.95	1.18	1.84	1.00	1.33	.78	.96	12.89

Credits go to National Weather Service, Climatological Records; obtained from Utah State Climatologist, Professor Arlo Richardson.

Table 2. Mean monthly, mean daily maximum, and mean daily minimum temperatures

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Mean monthly													
Ferron	22.1	25.8	36.4	37.5	56.0	65.8	72.5	69.6	63.4	51.0	35.9	26.5	47.7
Hiawatha	23.3	26.7	33.7	45.3	52.7	62.3	69.5	67.3	60.2	48.4	33.9	26.7	45.8
Mean daily maximum													
Ferron	35.8	38.2	49.1	60.9	70.0	80.7	87.5	84.2	79.1	66.4	48.8	38.5	81.6
Hiawatha	33.3	36.7	44.5	55.1	65.1	76.4	83.0	79.0	73.2	59.8	42.8	35.8	57.1
Mean daily minimum													
Ferron	12.0	15.0	23.7	33.6	42.6	51.7	58.6	55.0	47.7	35.8	21.9	14.7	
Hiawatha	15.3	18.2	22.8	32.1	40.9	50.7	57.3	54.8	48.3	37.6	23.5	18.3	

Credits go to National Weather Service, obtained from Utah State Climatologist, Professor Arlo Richardson

This data on maximum and minimum mean daily temperatures shows that although a rise of altitude results in a lower mean temperature, the sheltered position of Hiawatha compared to the exposed position of Ferron results in a modification in extremes at Hiawatha. While the mean maximum temperature at Hiawatha is consistently about 2 degrees lower than at Ferron, December thru February and about 5 fegrees lower March thru November, the mean minimum temperature is 3 degrees above that of Ferron, December thru February and 1 degree below that of Ferron, March thru November. This indicates that Hiawatha is relatively warmer for its elevation due to the protection of the surrounding plateau.

Snowfall records. Because there are no snowfall records kept at Ferron and Hiawatha, records from other stations in the general area--Stuart Ranger Station, Switchback, Upper Joe's Valley, Huntington Horseshoe, and Gooseberry Reservoir were consulted. Elevation, snow depth, and water content for the months of March, April, and May are recorded for various years in Table 3.

Although only Switchback and Stuart Ranger Station are on the snow course that affects the study site, the other three are included to give an idea of the snow depth at upper elevations (10,000 feet) on the Huntington Creek Watershed.

One can readily see by the dates (March, April, and May) that at lower elevations there is not only less snow fall, but that what snow does fall, melts sooner in the spring, April as opposed to May for higher elevations. This vast reservoir of potential water of the Huntington Canyon watershed, therefore has some year-round effect on the climate of the study site.

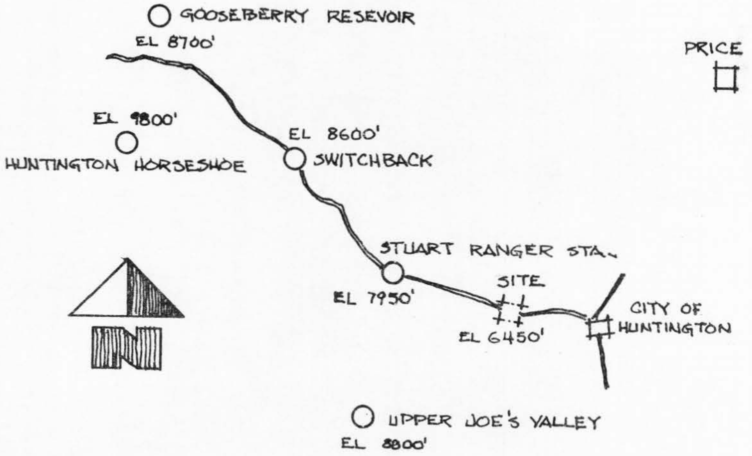


Figure 59. Location and elevations of snow survey stations relative to site.

Table 3. Snow survey measurements for Utah

Year	Mar			April			May		
	Date	Depth	WC	Date	Depth	WC	Date	Depth	WC
Snow Course/Huntington Horseshoe/Colorado River Basin No. 11K05, Elevation 9800'									
1930				4/01	60	20.5			
1935				3/28	68	25.7			
1940				3/30	70	28.1			
1945				3/31	75	24.1			
1950	2/27	50	18.7	3/31	60	21.6			
1955	3/03	54	17.8	3/31	54	18.2	4/29	56	20.4
1960				3/31	60	23.5			
1965				3/29	72	27.4			
1968				3/26	68	24.6			
Snow Course/Gooseberry Reservoir/Colorado River Basin No. 11K04, Elevation 8700'									
1925				4/01	31	15.5			
1930				4/01	52	18.5			
1935				3/27	55	18.0			
1940	2/29	56	18.2	3/30	52	20.6			
1945				3/31	58	19.0			
1950	2/27	52	20.6	3/31	60	27.9			
1955	3/03	49	14.2	3/31	50	15.9	4/29	39	14.6
1960	1/28	24	5.5	2/25	48	11.9	3/31	44	17.1
1965	1/27	54	15.9	2/25	53	18.2	3/29	63	22.5
1968	1/29	34	9.7	2/27	55	16.6	3/26	61	21.5

Table 3. (Continued)

Year	Mar			April			May		
	Date	Depth	WC*	Date	Depth	WC*	Date	Depth	WC*
Snow Course/Stuart Ranger Station/Colorado River Basin No. 11K27, Elevation 7950'									
1955	3/04	27	6.6	3/31	24	7.7	4/30	0	0.0
1960				3/28	12	4.2	4/24	1	0.1
1965				3/30	43	13.8	5/03	0	0.0
1968				3/27	29	8.4	4/29	17	6.3
Snow Course/Switchback/Colorado River Basin No. 11K26, Elevation 8600'									
1955	3/04	42	12.7	3/31	45	14.8	4/30	28	11.6
1960				3/28	31	11.4	4/24	19	5.8
1963				3/30	60	20.2	5/03	31	13.0
1968				3/27	49	16.5	4/29	51	19.2
Snow Course/Upper Joe's Valley/Colorado River Basin No. 11K29, Elevation 8800'									
1956	3/02	38	9.6	4/04	25	7.7			
1960	2/27	39	9.3	3/29	27	8.9	4/26	4	1.3
1965	2/24	44	13.3	3/29	49	15.8	4/29	32	12.1
1968	2/27	36	9.4	3/26	34	10.5	4/26	27	10.3

*WC = Water Content.

Credits to U. S. Dept. of Agriculture as follows:

Snow Course/Huntington Horseshoe/Colorado River Basin, pp. 115-116.
Snow Course/Gooseberry Reservoir/Colorado River Basin, pp. 112-113.
Snow Course/Stuart Ranger Sta./Colorado River Basin, p. 128.
Snow Course/Switchback / Colorado River Basin, p. 129.
Snow Course/Upper Joe's Valley/Colorado River Basin, p. 130.

Solar radiation. No records of solar radiation are kept in Emery or Carbon Counties, so Salt Lake data was examined. The average solar radiation for Salt Lake City for the months of January thru December are shown below. These are given in gram calories per square centimeter per day. (See Table 4.)

Salt Lake City is located at approximately 40 degrees latitude, while Huntington is located approximately 39° 30' latitude north. Therefore, the amount of solar radiation is about the same. Huntington should have a little more radiation because it is located a little further south.

Winds. Although there are other winds that will and do affect the study site, "the prevailing winds are generally from the southwest with the normal up and down-canyon variations." (Dept. of Interior, 1972, p. 11) The dominant wind immediate to the site will be the down canyon wind from the northeast according to records kept at Huntington. The average wind speed is 10 to 15 mph but occasionally, there is a severe wind of up to 50 mph which causes some serious damage, according to Professor Arlo Richardson, State Climatologist for Utah. Wind velocity and direction records have been kept at the study site the last two years, but they are not available at this time.

Climate analysis. This application of climatology is mostly concerned with the microclimate of the site, how it affects plant material, and how it affects engineering/mechanical functions of power plants. The question is: can plant material grow on this site, how does the solar radiation quality affect PM, how much precipitation is there, what kind of plant material can grow here, does it need irrigation, what effect does wind have on the plant material, on

Table 4. Average solar radiation (Salt Lake City 40^{o} lat)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
351	281	431	497	632	616	690	589	478	357	259	154

Source: Richardson, 1973.

the site, how does the microclimate affect other functions on the site, if at all?

In dealing with an answer to these questions there are two basic criteria that are pertinent: water budget, and heat budget.

These are derived from a complicated method of computation but basically they break down to: (1) Heat = Solar Radiation (air temperature, ground temperature, and radiation that strikes the plant). (2) Water = Precipitation in the form of rain, snow, dew, and fog. (3) Wind (direction and speed). These are the basic climatological phenomena that affect the Heat and Water Budget.

One can see from the brief data presented that there is more than sufficient sun light (solar radiation), that there is a temperature range normally compatible to plant material. There is a low amount of precipitation (on the border line of being critical for the survival of most plant material)--less than one inch. In addition, low rate of precipitation combined with temperatures in the 80° to 85° F. range during the months of June, July and August is on the border for survival of most plant material. Since the study site is located on the border of the desert, irrigation would be necessary if large amounts or varieties of native vegetation are to be used in landscape efforts.

Power plant components

First generation unit.

> Generating Station: The first 430-MW unit of a thermal-electric generating station known as the Huntington Canyon Generating Station . . . is under construction by the Utah Power and Light Company . . . in Emery County, Utah, approximately 29 miles

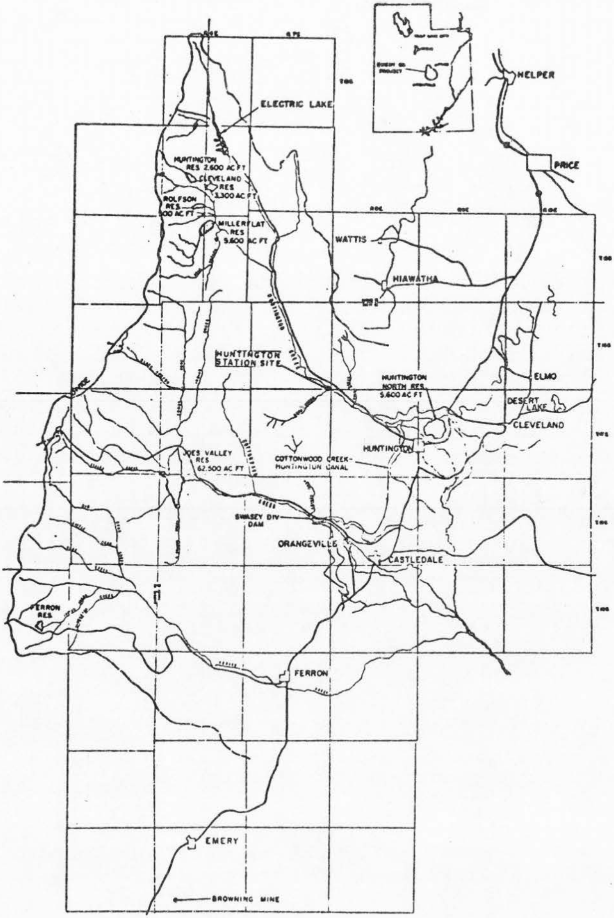


Figure 60. Huntington SE Station. (Dept. of Interior, p. 3)

> by road southwest of Price, Utah . . . . Ground was broken for the first 430-MW unit March 8, 1971. The first unit is approximately 75 percent complete as of October 1, 1973, and is planned to be on line in 1974. The Company's present load-growth projections indicate a second unit will be needed by 1977. The Station may ultimately have a 2,000 megawatt (MW) capacity . . . (Dept. of Interior, 1972, p. 1)

Major components. The major components of the Huntington Power Plant are:

1. Four units for power generation of about 430 megawatts each. Each unit includes a coal burning furnace with a high smokestack where the water is super heated; a generating structure where steam turbine and generator are housed; and the low profile water cooling structures out back.

2. Water source (dams, holding basins, pipe lines, creek, etc.)

3. Coal mine, coal storage, coal conveyor system.

4. Major access road, layout, and parking.

5. Fly ash control system, with resultant piping system and settling pond.

6. Sewage treatment plant and holding basin.

7. Substation or switch yard.

8. Extra high voltage transmission lines out of the study site.

9. Administration building.

Minor components. The main components of the HPP are components such as cooling towers, chemical treatment building, raw water pumphouse, the temporary concrete batch plant, etc.

Power plant layout and design

PP site selection criteria/three basic criteria/requirements. When initiating the site location of a power plant, the three most basic criteria are (1) source of water, (2) source of fuel, (3) transportation for the fuel and supplies.

Water. In the case of the Huntington plant the source of water is Huntington Creek. A series of dams and holding basins, mostly located on the site, the major dam, however, is located several miles up Huntington Canyon, to the northeast.

Transportion and Fuel = Coal. Fuel for the Huntington steam electric generating plant is high quality, low sulfur coal. It is mined underground approximately two miles up the adjacent Deer Creek Canyon to the southwest of the plant site. After mining, the coal is conveyed by a belt system directly from the mine site to a stock pile at the mouth of Deer Creek Canyon. From there, another belt moves it to the furnaces in the generation units. There is an alternate fuel conveyor in case of emergencies. An excellent hardtop road for the use of trucks extends from the power plant to the mine. Supplies of building, construction, and maintenance materials are trucked by a connecting road from U. S. highway 31.

Fly Ash. When coal is burned, a precipitate called fly ash is produced. At the Huntington plant, this ash will be electrostatically collected in the stacks and then carried in solution in water through pipes and deposited in a settling basin. Here the fly ash will settle to the bottom, and the water either evaporates or is released back into Huntington Creek.

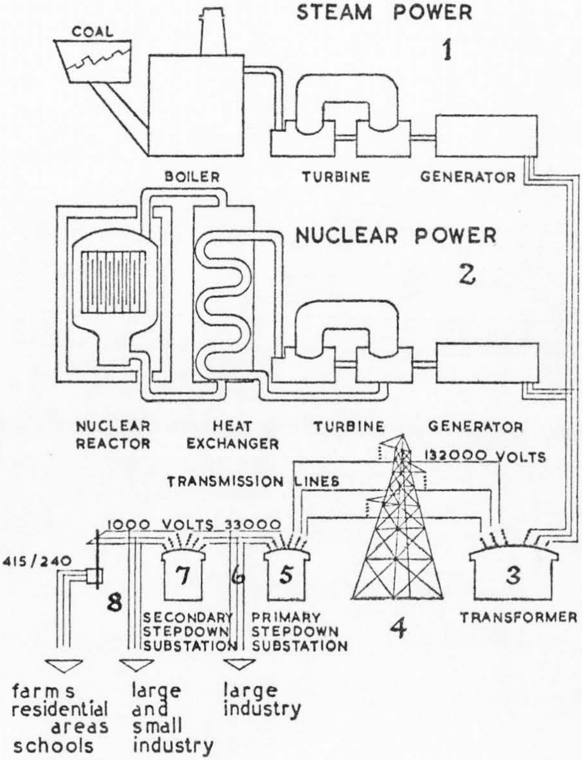


Figure 61. Drawing of power plant layout and design. (Crowe, 1958, p. 80)

Cooling towers. In the process of producing steam, of course, water is super heated, but it must be cooled before reentering the creek. Cooling towers are thus required to lower water temperatures before it is returned to its source.

Some of the water used at the plant may become contaminated in various ways--either by processes within the plant or sewage from cleaning requirements, bathing, washing, or elimination. Therefore, a sewage treatment plant and holding basin are provided.

Switch yard. Before the electric power can be transported through the extra high voltage power lines, it must be transformed from raw power (as it comes from the generator) to a suitable voltage (high voltage) for transmission through power lines, without high losses. This is the function of the on-site substation or switchyard. Substations also may break down the vast amount of raw power into units of power required by various private consumers, industrial operations, or municipalities.

Transmission lines. After the electricity is produced and transformed, there must be a delivery system for getting the electricity to the customer. Thus, extra high voltage transmission lines are established to supply the various cities and industries in the surrounding Utah counties. These transmission lines leave the site to snake across the mountains, foothills, and desert for miles around.

Administration building. In the case of the Huntington plant a separate and highly successful administration building, in terms of aesthetics and visual

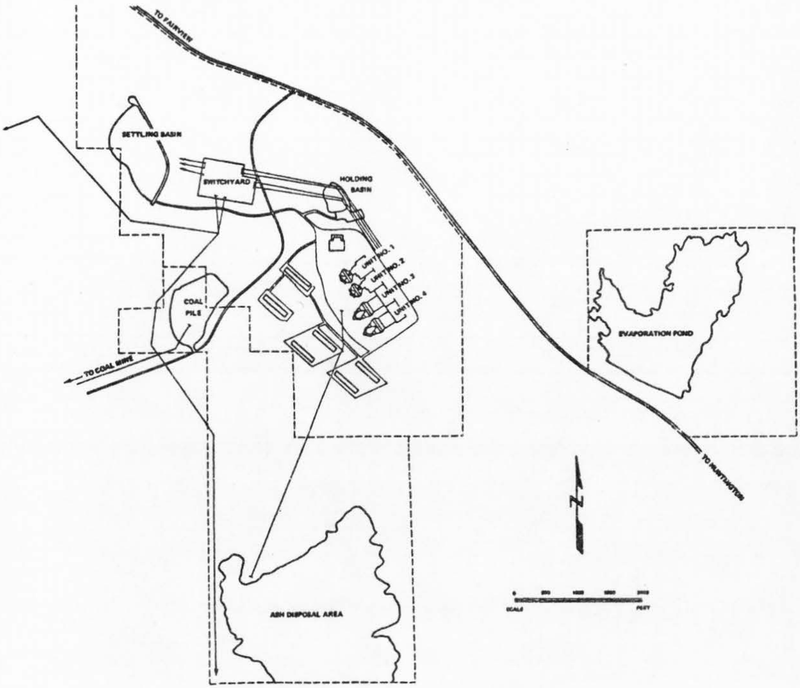


Figure 62. Huntington Canyon SE Station Site Plan. (Dept. of Interior, 1972, p. 4)

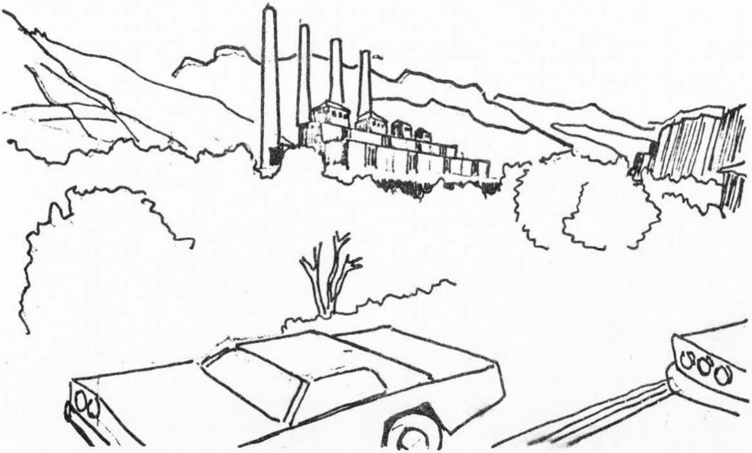


Figure 63. View of principal structures (stacks, furnace and generation housing) looking WSW from the POZ on the Huntington Canyon Highway (as it will be) after the four units are built.

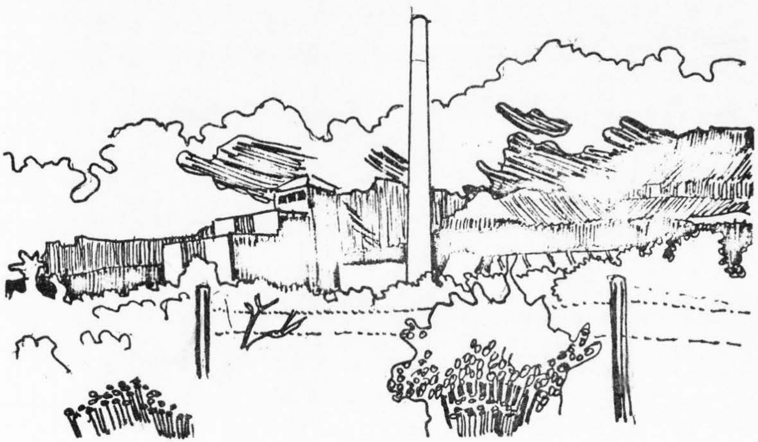


Figure 64. View of unit No. 2 now under construction, looking SSE, from the POZ on the side of the Huntington Canyon Highway.

appearance was designed for the purpose of coordinating and controlling this huge industrial complex and the people involved.

University of Utah environmental impact study

Introduction to Dr. Hill's air pollution study. Air pollution studies in the area of the Huntington Canyon Power Plant were carried out by the University of Utah in August 1970. Existing air quality and vegetation conditions were determined before the plant began operation to allow the researchers to measure the environmental impact of the plant when power is produced (Hill, 1971).

Objectives of the preliminary air pollution studies. Dr. A. Clyde Hill, Professor of Biology on the faculty of the University of Utah was the project leader. Objectives of the study included:

> Concentrations of SO_2 NO_x and O_3/Particulate
>
> 1. Determination of present concentrations of Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_x), and Ozone (O_3) and concentrations, sources and size range of particulate in the Huntington area. With this background information, changes caused by the new power plant can be measured and evaluated. There would then be a sound basis for a continuing serveillance and monitoring program.
> 2. Determination of the concentrations of SO_2 that cause injury to many of the important native species in the area; correlation of sensitivity of species to anticipated concentrations of pollutants.
> 3. Obtaining background data on vegetational associations of the area so that changes caused by the power plant can be evaluated.
>
> Since the Federal primary and State standards are designed to protect human health, the emphasis is placed on air sampling in Huntington, the population center. (Hill, 1971, p. 2)

Findings of air pollution studies. Dr. Hill and his associates found that there was no existing problem with sulfur dioxide (SO_2), or oxides of nitrogen (NO_2 + NO) in terms of State and Federal regulations, and that there was a substantial but not yet serious amount of ozone (O_3) present. The relatively high ozone concentrations do indicate that there is little leeway for additional ozone pollution, under State and Federal regulations.

1. Particulate matter. There was considerable particulate matter in the air year-round, and especially in summer months from dust, and winter months from inefficient home furnaces. In the summer, there is a great deal of dust coming off the desert, predominately natural dust and some fly ash from the Carbon Plant. Although fly ash and natural dust transmit light, visibility was slightly reduced in the area and resulted from the light scattering properties of the particulate matter and the soot which absorbs light. In the winter there is a great deal of soot generated from the town furnaces, mixed with the generally constant amount of fly ash from the Carbon Plant, and some dust.

The general effect was poorer visibility and less light reaching the ground or leaf surfaces of plant material. At times the particulate matter exceeded the Federal and State regulations considerably.

2. Vegetation background data/SO_2 damage.

> Background data on vegetation conditions in the Huntington Canyon area were obtained from replicated study plots which were located up to 13 miles from the plant site. The stands were selected to be representative of the dominant pinyon-juniper and spruce-fir plant communities so that the frequency of occurrence, species diversity, and percent cover could be calculated . . . . Vegetation was examined for the presence of symptoms which might resemble those of sulfur dioxide damage and to obtain background data on disease and insect conditions. (Hill, 1971, p. 4)

It was found that there were a number of such disorders operating and that generally plant material was not in good condition, also, that some were causing significant damage to and mortality of dominant plant species. Agricultural crops examined also showed similar symptoms (Hill, 1971). "General conifer decline and mortality were common at all elevations." (Hill, 1971, pp. 64-65)

3. Irrigated crops.

> Of the irrigated agriculture crops present, it was found that alfalfa was a good indicator of SO_2, and that apples were a poor indicator (could stand a large dose). Studies indicate SO_2 uptake rate of alfalfa is relatively high indicating that vegetation might be an important sink for SO_2." (Hill, 1971, p. 60)

The writer's observations concerning functional qualities of PM are as follows: Dr. Hill's findings in agricultural or irrigated crops suggest that plant material has the functional quality, when in mass, to be of great service and efficiency in drawing pollution from stack emissions, out of the atmosphere into the plant material, and on into the soil without serious damage to the plant material or the soil. In fact it will likely improve plant material and soil conditions. In this way stack emissions are recycled.

4. Species diversity. The researchers found that the greatest species diversity and percentage of cover occurred farthest from the site and coincided with the highest altitude, probably because of greater precipitation.

A mixed spruce-fir transitional community type exists in the lower montane zone. This type occurs in the canyon, between 2 and 1/2 miles and 5 miles from the site.

5. Soil samples. Soil samples collected for mechanical and chemical analysis showed: the soil to be composed of sand, silt, and clay, on the average 54 percent, 14 percent, and 32 percent respectively. The soil has an average pH of 8.0 and contains 8.1 percent organic material on the average (Hill, 1971).

Conclusion to Dr. Hill's Preliminary Study. In general, evidence of widespread, though not serious, damage and disease appeared throughout the dominant species. Many diseases and at least one chemical were operating in the area, including ozone damage to some species. Evidently the Huntington Canyon area is a harsh and unfriendly environment for the survival of plant material. The natural condition of the area, at this time, is largely unaffected by man. However, it is one of extremes; extreme drought at lower elevations; extreme natural dust particulate matter blown off the desert in summer; extreme change of elevations in a short distance; and extreme cold at higher elevations in winter.

Increased pollution would naturally cause increased stress and consequent damage to the existing plant material.

Writer's recommendations and observations. This final statement of Chapter IV is the basis for the recommendation that power companies become involved in the regional improvement of plant material communities surrounding their sites that are found to be in degenerate condition. Not only will this action draw the gratitude of the local and perhaps national populace, but it will also contribute to pollution reduction in the atmosphere, pollution absorbing potential and pollution absorbing capability of plant material, pollution absorption ability of the regional plant community surrounding the power plant site, and perhaps to a pollution-free environment. If improved or healthy regional plant community reduces or completely eradicates power plant originated pollution, it is obviously to the benefit of the power company to do so.

Summary

The following data and factors are discussed in Chapter IV. The major points are:

General physical description and physiographical site conditions/characteristics

1. A general physiographic description of the city of Huntington and the region round about.

2. A description of the Huntington Canyon Electric Power Plant site itself.

3. A physical description of the topography and other physiographic/ geologic data.

4. A brief discussion of plant material and plant indicators.

5. A discussion of the flora of Huntington.

6. Pointing out the soil conditions and erosion problems.

Plant material and climatology

1. Weather or climatic conditions

    a. precipitation

    b. temperature and effect of altitude on it

c. annual snowfall

d. solar radiation

2. Climate analysis

a. heat budget

b. water budget

Major and minor components

A discussion of the major and minor components of the Huntington Electric Power Plant.

First generation unit

1. Insight into land acclamation
2. Cooling water source
3. Transmission line
4. Socio-economic factors

University of Utah environmental impact study

1. Sulfur dioxide SO_2 /Nitrogen oxide NO_x/Ozone O_3
2. Particulate matter NO_x
3. Sulfur dioxide SO_2 damage
4. Species diversity
5. Soil surplus

Of course this chapter strongly supports directly objective 4 and 3e.

Chapter IV also indirectly supports objective 1.

CHAPTER V

CRITIQUE OF HUNTINGTON ELECTRIC POWER PLANT

Introduction

The purpose of Chapter V is clear. The previous four chapters have, first identified the problem, second reviewed the current literature and gathered design criteria data, third selected, identified, described, and analyzed physiographic factors influencing design, and fourth described and analyzed existing site conditions. The fifth chapter will bring this multiplicity of data to bear on the case study of Huntington in order to verify and test the site development design criteria identified and established in the previous chapters.

Review of Objectives

1. To identify and develop guidelines or design criteria for the site development of electric power plants and industrial complexes.

2. To determine an appropriate approach or concept by which to attack the industrial visual pollution problem.

3. To determine the proper way of using landform or topography.

4. To determine the proper way of using plant material to functionally perform in the following categories:

   a. Architecture

   b. Engineering

c. Climatology

d. Aesthetics

5. To determine the proper evaluation and application of power plant components.

6. To determine the appropriate evaluation, listing, and application of landscape architecture design elements.

7. To determine and define the basic components and/or elements of design in fine arts and common to all professional quality design.

8. To determine and analyze the following physiographic elements affecting power plant site development.

a. Topography

b. Climatology

c. Plant material

9. To determine how physiographic elements affect design criteria.

10. To determine site conditions of Huntington and their influence on design criteria.

11. To determine ways, approaches, or methods of design and site development (guidelines) by which to develop the site without destroying the ecology and natural beauty of the site.

12. To determine how to take advantage of these natural features.

13. To determine the appropriateness or degree of success of the design criteria by applying it to a critique of Huntington.

Critique--Aesthetics

Primary Observation Zone (POZ)

Primary location of POZ--major views. As explained in Chapter II, the POZ is the zone from which a person can see any element, in this case a power plant, from any normal observation point on this site and adjacent land areas. In this case, the major POZ in most cases occurs along the seven miles of canyon road that runs from the city of Huntington through approximately five miles of agricultural and orchard land, past the power plant site, and into Manti-La Sal National Forest. This road traverses Huntington Canyon mainly along the northeast as it passes the site. The major structures at the power plant site are located approximately 500 feet to the southwest of the road.

Secondary location of POZ--minor views. Less frequently, the site can be viewed from the minor dirt roads in the area, primarily frequented by hunters, amateur explorers, tourists, and local ranchers or farmers. These same people may be, at times, viewing the site from the top of the 9,000 + foot plateaus surrounding the site on three sides that tower above the site about 3,000 feet. In some cases, they may view it from the rolling terrain adjacent to the site proper. The major visual concern then is for those driving, hiking, walking, or biking along the main road (Utah Highway 31).

Primary view--scenic views. The primary view from the road is generally a horizontal or eye level view, having the greatest impact just opposite the power plant and for the two miles to either side of this point.

TOPO characteristics of road--scenic views. The road undulates as it leaves the city of Huntington, and offers only occasional glimpses of the stack of the existing first unit, in the hazy distance, until the primary POZ is reached.

View of the site from road--scenic views. Since Huntington is located at an elevation of 5,800 feet, and the power plant site is at an elevation of 6,400 feet, the viewer gets a generally uphill view of the power plant, seeing it from below until well past (to the northwest) of the site entrance. At a point on the road, exactly opposite (at right angles to the main structures) the power plant foundations are 100 feet above the road, built on top of a partially natural, partially man-made shelf or bench, which drops sharply down into the Huntington Creek and then rises slightly for approximately 400 feet to the road. One half mile above the site entrance the roal elevation is 6,500 feet and one and one half miles above the entrance the road elevation is 6,700 feet. This latter portion of the road offers a POZ that looks slightly downhill at the site proper.

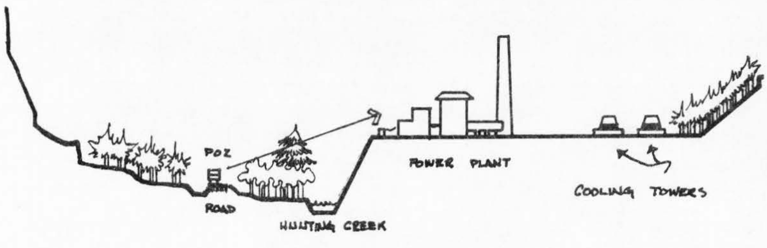


Figure 65. Cross section view of site looking east.

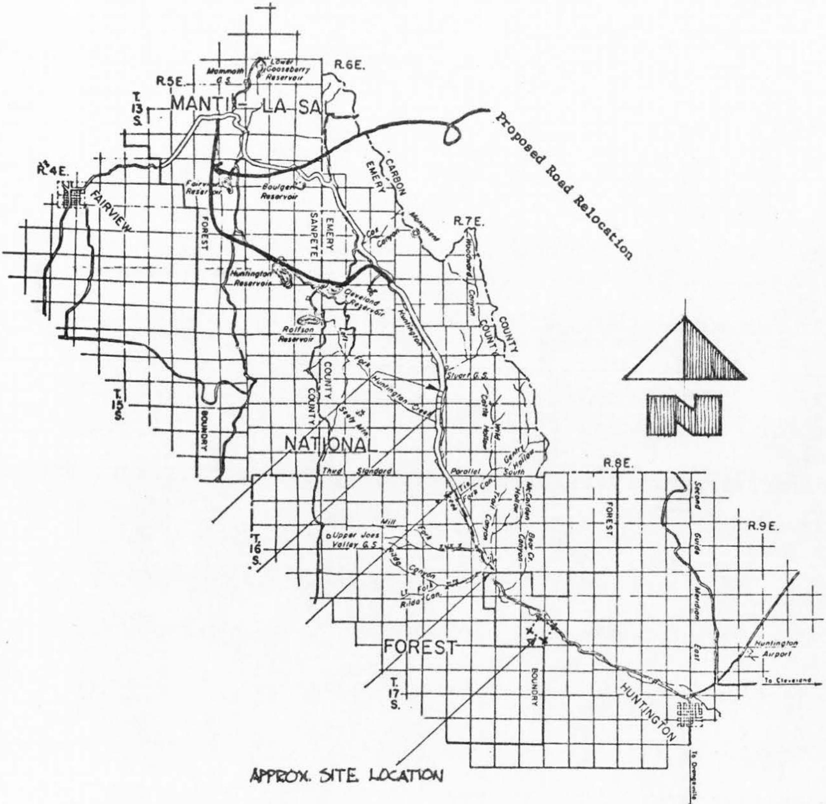


Figure 66. Manti-La Sal National Forest, Emery County. (Dept. of Interior, 1972, p. 21)

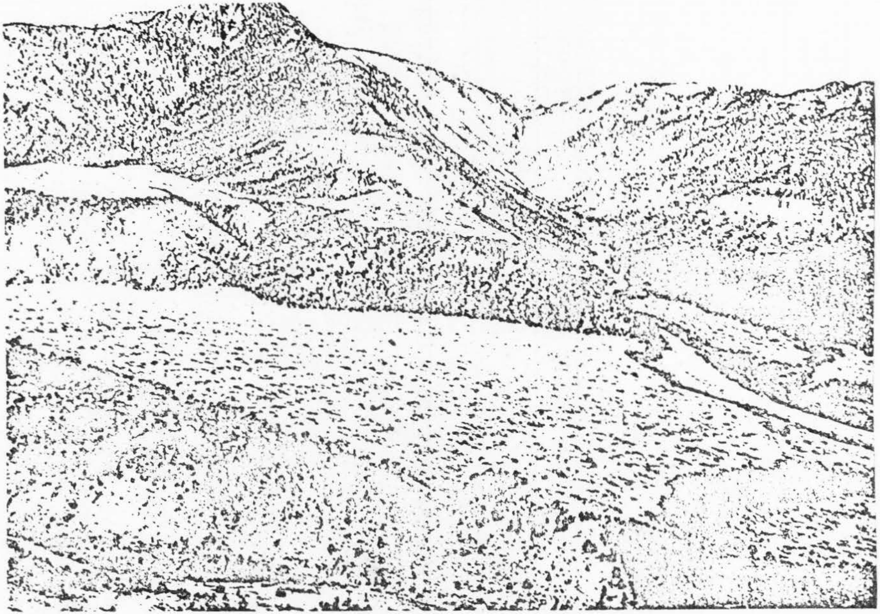


Figure 67. Huntington Canyon Generating Station Site.

Figure 68. Detailed Site Plan and TOPO of Units Immediate Site showing Unit 2, Administration, and POZ on road. (UP&L, 1972, no. p.)

Impact of major components (principal structure)

Main generation units. The only structures that are going to have a major impact on the site in terms of a visual or aesthetic impact, are generation units 1, 2, 3, and 4 with their related housing, and stacks. Intruding to a lesser degree, because it is lower, is the administration building.

As can be seen from the plan view of the Huntington Power Plant, the four units are connected together and stand in a row. Unit 2 is the first unit to be built and is almost completed at this time.

Administration building. The administration building is also completed and stands just to the northwest of the four scheduled main generation units and at a 45^{0} angle to them. Visually, this seems to be a good relationship in that the administration building has a separate function from the generation of power. Although the administration building has a separate architectural treatment from the generation units, its juxtaposition and simple shape brings it in harmony with the general architectural treatment.

In addition, the administration building is located in such a position as to be the first building that one approaches after checking in at the guardhouse. It has a distinctive color, texture, and shape, therefore easily located. It is the logical first step for people in any approach to the workings of a power plant. Both the administration building and the generation units are of simple basic shapes and therefore "read well" visually.

Elements of disharmony: There is an element of aesthetic disharmony, however, in regard to other (the average?) power plant; in many cases the

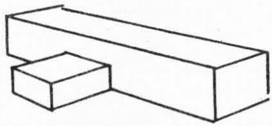


Figure 69. Typical administration structure added onto generation structure.

administration building and the main generation units are physically tied together. This combination treatment comes off poorly because the two structures are: (1) somewhat different in proportion and size; (2) their internal activities are in conflict; (3) the administration building is often of a more refined architectural treatment and of a less rough, less raw industrial function combined with; (4) a different color and texture and therefore is not in harmony in any way with the main generation units, even though it is tied in physically; (5) in these cases there is no transition area between structures or functions; and (6) each structure tends to disrupt the otherwise clean simple lines and configuration of the individual structures, which may appear to some designers and viewers like having a finger attached to one's foot.

Impact of cooling towers as major components. Cooling towers are of several configurations. Often in the east and also at the Trojan site in Oregon, a form of Hyperbola is used, in a concrete form, standing as high as 100 to 200 feet in the air or even higher. This type of cooling tower would definitely be a large scale or cosmic structure and would have to be considered as one of the primary elements in the visual composition. However, the reason for not using this type of cooling tower at Huntington Canyon is that these hyperbola cooling

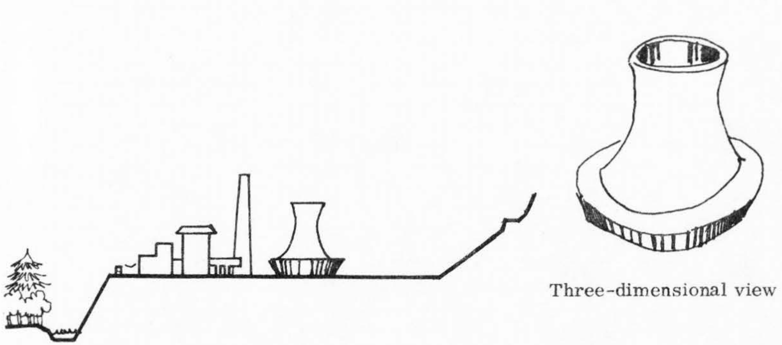


Figure 70. A typical hyperbolic cooling tower

towers are of the natural profile design (type); they require a higher atmospheric pressure differential than exists at Huntington and are efficient only at lower elevations.

Non-impact of cooling towers at Huntington/minor components. In the case of Huntington Power Plant, the water cooling towers are of the low profile mechanical draft type, similar to ultra large air conditioning units. According to the site plan of the scheduled completed plant, these are built in series or groups, in a straight row like soldiers, on a concrete pad. The water cooling towers are built as a unit, one unit for each of the first two generating units (1 and 2). Two cooling units will be built for generator units 3 and 4, probably because units 3 and 4 are designed for larger generation capacity. In any event, these cooling towers will have little if any visual impact as they are located far back on the bench and are also blocked from the POZ by the main generation units which are the principal large-scale structures.

Elements of order

Basic principles of design--visual design factors. (1) Sequence, (2) Repetition and Rhythm, (3) Balance, (4) Shape, Size and Scale, (5) Proportion, (6) Texture and Color, (7) Hierarchy.

> Along with land use and circulation, visual design factors and natural elements must be studied in structuring the site plan. It should be viewed as a total organization of space formed with buildings, earth, rock, water, and plant material. It must be structured so that its parts not only work together but are visually unified and coherent as well. (Rubenstein, 1969, p. 69)

1. Sequence. There are two ways sequence works or can act upon this site.

First, there is the sequence of views from the POZ on the main road going west, leading up the canyon from the city of Huntington, past the power plant site, into Manti La-Sal National Forest, and/or driving east. This is, as well, a sequence of position in the overpowering spaces defined by the plateau walls, and to a lesser but more personal degree, those spaces defined by the plant material and landform of the immediate POZ environment.

Second, there is also the possibility of the sequences of space and views on site. This would involve the decision to drive into the site. There is no barrier other than a psychological barrier to entering the site, and after entry, there would probably be no objection to entry beyond the cyclone fence surrounding the power plant itself.

2. Repetition and rhythm--principal visual structures/plant mass and landform.

2A. Repetition: There is the repetition of four repeated shapes, the first two somewhat larger than the second two.

1) four stacks

2) four furnace housing structures

3) four divisions to the generation housing structure

4) four scrubbers, but these are not generally visible.

To go on:

5) Altogether there is the repetition of large structures which includes the administration building as well as these afore-mentioned principal structures.

6) There is the repetition of horizontal steps; the tallest and visually highest in elevation being the plateaus, then the stacks, furnace housing structures, turbine/generation structure, the bench, and last the base plane/road and canyon floor.

7) repetition of the tree mass and color

8) repetition of planes and slopes of the plateau

9) repetition of the serpentine pattern of the Huntington creek and the associated deciduous plant material and landforms (banks, etc.)

10) repetition of the vertical and horizontal curves of the roadbed.

2B. Rhythm: There is rhythm throughout the site, starting with the principal structures:

1) rhythm of the stacks approximately equal distance apart, the first two large and then two smaller.

2) rhythm of furnace structures, two large and two smaller.

3) rhythm or vertical pattern of the facing plane of the generation/ turbine structure, white, dark, white, dark/plane, window, plane, window.

And to go on:

5) rhythm in the dominant plant material/shape, color, structure, texture, applies to evergreen and deciduous.

6) rhythm in the plateau fenestration/alternating indent and protrusion, which also results in dark and light pattern depending upon how the light strikes it (time of day).

3. Balance--an element of order. There are two aspects of balance, symmetrical and asymmetrical. "In symmetry equal and like elements are balanced on either side of an axis. Asymmetry is the balance of unequal and unlike elements on opposite sides of an axis." (Rubenstein, 1969, p. 69)

First, the elements of the principal power plant structures are all symmetrical as are most of the other industrial units on this site as they relate to themselves. Example: switchyard structures/cooling towers, etc.

Second, the site layout is in asymmetrical balance (juxtaposition of structures and/or units to each other).

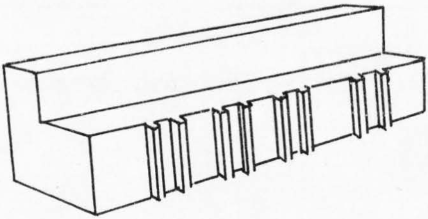
4. Shape, size, scale--architectural configuration impact of components.

> The characteristics of objects in the landscape determine the quality of a space and its enclosure. What is the shape or form of the space? Is it rectilinear, curvilinear, or triangular? What is the size of the space? The size of an object or space is relative; it is large or small according to the standard with which it is compared. Size also depends

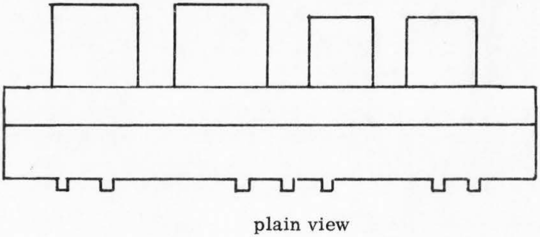
on the distance of an object from the observer, whereas scale denotes relative size. Scale is therefore generally based on the size of the average observer--5 feet 9 inches. (Rubenstein, 1969, p. 70)

4A. Main generation unit: For the purpose, convenience and analysis of shapes in this thesis, the main generation unit has been subdivided into these general component parts: 1) generation/turbine housing and furnace/boiler housing; 2) scrubbers; 3) stacks.

1) The shape of the main structure is a horizontal rectilinear box or solid, backed by four vertical solids.



3-dimensional view--generation/turbine



plain view

Figure 71. Generation turbine and furnace housing.

The front panels have a geometric fenestration pattern. Three groups of black holes or windows punched into the white structure, dividing it equally into four parts which produces a pleasing effect. Each window grouping is divided by a series of pillars or beams.

The three dividing window panels also divide the four taller and separate sections or structures to the rear. These also have windows that read as horizontal patterns/ribbons on tall vertical rectilinear shapes.

2) Low horizontal structures to the rear of the coal burning furnace housing are the scrubbers. Scrubbers are a device whereby the particulate matter in the exhaust gases of the coal-burning furnaces is charged electrostatically and then gathered on a belt of opposite charge and carried away via a water-fly-ash slurry to the fly ash settling basin. Thus more than 90 percent of the fly ash produced is prevented from entering the atmosphere via the stacks. These scrubbers tend to be out of view of the POZ.

3) The stacks are of the familiar design, 600 + feet vertical structures, cylindrical in shape. They are rather broad at the base and gradually become more narrow at the top.

4B. Administration building: The administration building is a very simple basic shape, at the same time dignified and solid in appearance (as perceived visually). It is a basic (low profile) horizontal rectangle with a copper type Mansard roof, sloping down more than half of its height toward the ground plane.

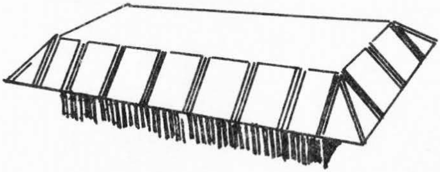


Figure 72. Administration building.

4C. Low profile cooling towers: Since the cooling towers are of the low-profile variety, they are not a viable element among the cosmic scale structures and have no visual or aesthetic effect on the POZ.

4D. Switch yard: The switch yard (substation) structures and related paraphernalia are structures that vacillate between human scale and cosmic scale. In the case of Huntington their mass or the yard is approaching cosmic scale in horizontal distance, but because of the newly designed cast aluminum oxidized frames they are of a low profile shape and therefore they do not appear higher than the surrounding plant material. Their shape is simple and tree-like in appearance and they are effectively screened by the existing plant material, even in winter. So although the switch yard can be classified as a cosmic scale/major component, it is negated by its low profile and site/PM treatment.

5. Proportion.

> It is the ratio of height to width to length and may be studied in drawings or models. Shape, size, scale, and proportion in the formation of structures or space must be considered in design. (Rubenstein, 1969, p. 70)

Although the overall shape of this power plant is not a thing of architectural beauty, because of its simplicity of shape/pure shape, and generous proportion, it reads well visually in a utilitarian sort of way. But it is because of its scale that it is an interesting structure. That is to say, the proportion is read on a cosmic scale, otherwise it would be a nothing structure.

First, because industrial structures often have an inherent attractiveness/ quality of rugged immensity, a gargantuan structure exposed to the elements, in spite of their negative aspects, they can be handled very well when thought is given.

Second, huge individual shapes: The pure individual shapes which to go make up the visual package of the power plant are satisfactory to well proportioned and generally pleasing to the eye.

Third, also to be considered is the proportion of the power-plant principal structures in relation to the space defined by the bench and by the surrounding plateaus. The height of the plant structures to the height of the plateaus. It is readily evident that both the scale and proportion of the power plant structures are in a pleasing aesthetic and physical relationship to the vast space and rough physical scenic characteristics of the site environment.

6. Texture and color.

6A. Color as an element order--impact of color on industrial development. Color is important in any industrial complex development. In some cases color is used as a code to identify different functions and also danger zones.

1) Impact of color code: In an industrial development where a color code is the predominant visual/aesthetic factor, this treatment is often successful aesthetically. Even in a case where color is used a different way, a color code can work on a small scale visually, because it does not become the dominant visual/aesthetic factor.

2) Impact of color as a unifying element: In the case of the majority of industrial development though, color should be used as a unifying element because little else is functioning as a unifying element. (Of course, plant material is also a unifying element, partly because of color.)

3) Analyzing and developing color strategy: Factors to be considered in analyzing and developing color strategy are what the predominant colors of nature are--sky, mountains, earth, trees, etc. Color should have quality, a dignity. A criticism of the majority of industrial color treatment is that they have no dignity. Color can also identify the use or general image of a public utility or industry.

4) Dignity in color: An example of color dignity might be dark colors, such as dark green or dark brown. However, light colors can also have dignity. For example yellow can have dignity and at the same time be very much an identity (example, Caterpillar Corporation yellow is the corporation identification and at the same time is very clearly a factor in safety because the machinery is easily spotted by construction workers even in very dusty conditions.

5) Concept of industrial color treatment: Although there are several options or approaches open in industrial color treatment, and they should not

be ruled out as options. The best approach, as noted by Crowe and Halprin (1958, 1970), in rural or wild natural environments/zones, is to blend the industrial complex with the background. The way this is done is to pick the dominant color or colors of the rock, landforms, plant material, and sometimes the sky, if it is judged the dominant background, and any other factor of color which might affect the environment and apply it to the structures. This has to be considered/ analyzed in the context of change of season and selection of the dominant and most compatible color or colors should be the result.

6) Individual sites require individual color treatment: The most important factor to remember in the consideration of color is that each environment is or may be different from all others, that what works in one part of a state may not work in another or even in the same county.

7) PP&L--example of individual site color requirements: In the East, Pennsylvania Power and Light developed two principal colors for the majority of their work, a semi-dark and a light gray green for industrial equipment. This has worked very successfully in Pennsylvania and probably is effective for the northeastern United States. This color/shade or a similar color/shade was picked up by other utilities and/or industrial suppliers and, for example, has been applied to the Carbon Plant in Carbon County, Utah.

8) A negative example of color: At the Carbon Plant the predominant environment is sheer rock walls, cliffs and moutains, which are a kind of light pink brown shade with some darker shale and black coal seams mixed in. The plant was painted pastel green and although both shades of color have pastel in

common, the green against pink brown is a poor choice to visually blend a power plant into its surrounding environment.

Impact of color on industrial identity. From this discussion of color, it might be asked, what happens when an industry or company wants to develop an identity through color or symbol? The answer is to develop a unifying company-wide/industry-wide symbol and/or a color combination identifying the company or industry.

1) Symbol and color--impact of color on identity: The following is a list to identify the areas where color plays a most important part in the public image of the power industry, and the attitude and working conditions of power company employees:

a. employee work uniform

b. company cars and trucks and construction/maintenance vehicles/equipment

c. signs

d. symbols

e. advertising

f. printed material

2) Color and symbol--impact of color on employee: These are the areas of concern in the electric industry where the choice and conscious intelligent use of color can greatly upgrade both the image and employee self esteem, feelings, and working conditions.

3) Symbol and color--identity and operational symbols: Perhaps thought should also be given to recognized company and/or industry-wide symbol for each operation such as substation, switch yard, power plant (a. coal, b. gas, c. oil, d. nuclear, e. geothermal), main office, sub office, etc.

4) Symbol and color--operational identity example: For example, Baltimore Gas and Electric has a combination sea shell and nuclear symbol, for their new Calvert Cliffs nuclear power generation plant, located on the Chesapeake Bay in Maryland. This symbol of course immediately identifies the nature (source of power) of the plant, and also gives the predominantly recognized identification of the general area.

The sign is very sophisticated in layout and color contrast, and thus gives a pleasing, meaningful, and dignified identity or image to the site, and to the Baltimore Gas and Electric Company in general.

5) Symbol and color--negative use of color for identity: Power stations themselves, in general, should not be used to display the company or industry-wide color combinations or identity/image, except in the signs, because the job of color in a power plant is to blend the structures with the site environment.

6) Symbol and color--positive use of color for identity: Color used in signs, letterheads, calling cards, cars, trucks and equipment, symbols, and advertising, etc. can do the most effective and valid job of projecting the image of the company/corporation by following through with the selected color combination and symbol.

7) Symbol and color--poor color choice: The color not to choose is the shade of gray (medium light nothing gray) common throughout the electric utility and some other industries. For some reason this shade of gray and her ugly sister silver, were used extensively nationwide in most early industrial applications, probably early on in industrial paint development, because of the limited technology of paint manufacture, and also because of the view taken by industry in general, to project a no-nonsense efficient and practical image, and perhaps because industry management was not aware of the power and quality of color to project a dignified and impressive image. Something like the idea behind solid and grand bank buildings, solidarity, trustworthiness.

8) Symbol and color--degrading use of color: The shade of gray in general use by the electric industry in the United States has absolutely no distinguishing characteristics except, perhaps, a degrading characteristic (this especially applies to employee uniforms, office equipment, cars, and trucks).

9) Symbol and color--gray with dignity: Gray can have dignity, especially if it is a dark shade of gray. So this does not rule out gray as one of the possible color choices altogether. However, gray has been run into the ground in its present form, shade, and application.

Influence of color and form--of topography and plant material on principal structures (major components).

1) Positive UP&L aesthetic environmental effort: At the Huntington site a great effort, it seems, has been expended in considering the newly recognized needs of the environment and industry. This does not mean that all

problems have been solved, but a genuine attempt has been made and a large sum of money has been spent in this effort.

2) Color and form--color of structures: Apparently a semi-dark brown green has been selected for principal structures, the stacks, scrubbers, and furnace housing. These are predominantly vertical structures. The forward generation and turbine housing has been designated an off-white. The administration building has been designated for a light yellow-green or lime-green roof, which is the major visual factor of the administration building from both the POZ on the road, and from anywhere in the foothills or steep sides of the surrounding cliffs/plateaus.

3) Color and form--influence of topography and plant material as vertical and horizontal forms: The vertical forms of combination furnace housing, scrubber, and stack will, in the majority of cases be viewed against the vertical thrust of the north-facing slopes of the plateaus, or against the lower foothills and plateaus to the southeast. Here the sky will be a factor. The predominant color of the cover on this landform is dark gray-green, because the principal plant material is the juniper and pinyon pine. This brown-green color is obviously a good choice because of the blending effect, subduing the harshness or "out of placeness" of the industrial structures.

Influence of TOPO and PM color and texture on principal structures (major components). The horizontal shape of the forward generation/ turbine housing will be viewed against the dark shape of the furnace housing and also the plateau or foothills to the southwest,south and southeast. In analyzing this color selection, it appears that the architect may have been influenced by the very light colored, barren and harsh vertical slope of the plateau to the northeast (southwest facing slope). Here the rock is very soft and most of the slopes are a sandy texture and shades of light pink, yellow-white, light gray, or light brown.

Influence of TOPO and PM color and shape. Another factor in this color choice might have been the pattern the plant material makes against the soil of the foothills at the base of this plateau. The plant material is sparse and the white/light color soil shows through in large spotty chunks and shapes. Perhaps the architects wanted to repeat the color of the 100-foot slope just below the power plant, as the horizontal shape of the structure repeats the horizontal plane of this bench slope. Yet another factor might have been the desire to have strong contrast between the repeated vertical shapes behind and the horizontal shapes forward.

1) Influence of TOPO and PM color on administration building: The low horizontal shape of the administration building is usually viewed against the gray subdued green-yellow of the pines higher up and behind the site and also the majority of deciduous material in front of and falling away below the administration structure. This plant material would be light yellow-green in the spring, medium dark yellow-green to gray-green in the summer, predominantly yellow in the fall, and light to medium gray-brown against white in winter.

2) Influence of TOPO and PM color and texture on switch yard: Another group to consider, although not prominently in this scale category, are

the switch yard structures. There are two color factors working here: First, the heavier, more solid, vertical support structures appear to be an oxidized medium gray-brown color. Second, the other less solid and less dominant structures are polished aluminum or silver in color and are both vertical and horizontal. This yard is viewed through a screen of deciduous (willow and cottonwood) plant material with very similar form and color to the structures. They therefore effectively screen these structures, both in form and color. Behind the yard is open land, rocks, and sandy clay soil, white to light in color and very close to the polished silver in hue as perceived by the eye. Because of this the structures are effectively screened or blended into the background.

6B. Texture.

Texture and the POZ: Detail texture is largely lost to the eye at the main POZ. The only effective texture applying to the POZ is large mass dark and light patterns.

Influence of texture on principal structures: This idea of texture has been well exploited at Huntington, in that the white forward horizontal geometric shapes have been broken up into four uniform divisions by dark window spaces. And, the change of plane from vertical to horizontal has been liberally indulged as the wide visual distance allows.

Horizontal and vertical forms create texture: In the rearward vertical shapes, horizontal ribbons or bands of window have been exposed against the vertical form of the furnace structure.

Critique--Architecture

Arch functions of PM

Architectural properties or functions of plant material are actually visual and structural: forming spaces, structuring the flow of traffic of the spaces one into the other and all into a unit or landscape of function/or purpose, defining and delineating spaces, and enhancing the architectural structures.

Arch materials and what they do. "Wood, wood products, masonry, concrete and metal are used by architects to give shelter, warmth, and protection. To direct, filter, or block views." (Robinette, 1973, p. 11)

What PM does

Plant materials

> do provide a feeling of shelter and protection, more importantly, they direct filter, or block views. Under the canopy of a shade tree, one senses a feeling of shelter. Children who play hide and seek behind tree trunks and bushes enjoy the feeling of concealment. Vistas and panoramas are enjoyed more when first glimpsed through openings and then revealed in their entirety. Hedges of plants may be used to screen undesirable views of junkyards or desirable views of bikini-clad beauties sunbathing.
>
> Basic to the planting designer is an understanding of plants as architectural material. It is easy to walk on turf (the floor), under the canopy of a shade tree (the roof), but it is difficult to see through a hedge (the wall). These ideas provide an elementary understanding of the functional uses of plant materials as architectural elements. (Robinette, 1973, p. 11)

Space articulation.

> Any element, natural or manmade, which is able to form a floor, wall, or ceiling, may be used to articulate space.

> Buildings, walls, fences, earth-forms, rocks, water, plants, and changes in ground elevations are all used to indicate the parameters of external space. (Robinette, 1973, p. 16)

Space perceived.

> Factors involved in creating the sensation of space are the space itself and the manmade or natural objects and elements which define or articulate it. Variations in the quantity or the quality of either or both of these two factors are the essence of space modulation or manipulation.
>
> Space is visually perceived three ways. . . . The first of these is flat, two-dimensional space, such as a painting lacking depth. In all pictorial phenomena, space may be depicted or illustrated, but never actually formed. The second of spatial perception is plastic, three-dimensional convex, and is best illustrated by a piece of sculpture. The observer experiences the space from without as he moves around the finite shape viewing three-dimensional relationships stereoscopically. In the case of traditional sculpture, the observer does not move through it, but looks upon its inner-spatial modulation from exterior vantage points. The third type of space perception is three-dimensional concave, kinetic space, which the viewer, from vantage points within the space, experiences and comprehends it subconsciously as spatial sensation; or as Goldfinger phrases it, ". . . when space is enclosed with the skill of an artist . . . then spatial sensation becomes spatial emotion and enclosed space becomes architecture." (Robinette, 1973, p. 16)

Two categories. The architectural applications of plant material to the Huntington Electric Power Plant fall into two categories: (1) Macro scale over all view of the total power plant site; (2) Micro scale spaces within the large scale site which are not seen from the main POZ positions.

(1) The macro scale overall view of the total power plant site should be viewed in the context of:

(a) native plant material because of the basic criteria, is the best architectural visual and aesthetic answer to power plant site development in most cases, especially in a rural setting/environment such as Huntington. (It is practically wilderness.)

(b) masses of plant material (Crowe, 1958) because only massing can compete and be compatible with the cosmic scale of the principal power plant structures.

(c) construction scars and disturbed areas. In this all areas not otherwise designated, should be replanted with the native Utah juniper and pinyon pine (and associated shrubs and crested wheat grasses) for erosion control and visual order or unity.

(d) Fenced in area. Visually there should be no difference between land on the inside of the fence and land on the outside of the fence (Crowe, 1958). The goal is to eliminate the fence as a visual component or barrier, while retaining its function as a safety factor, limiting access by people and animals, and defining a kind of work zone or industrial functions space.

Negative uses of fences--the problem with most electric power plant site development is that the fence is pushed right up against the boundary line of the property, allowing no transition zone (allow at least 20 feet for plant material) and therefore no chance to soften the negative visual/psychological effect of the cyclone fence on the viewer/POZ. Fences also impose an arbitrary geometric pattern upon the landforms and site.

PM soften negative impact of fences and define structure spaces. To further soften the negative visual impact of the fence there must be a second transition/planting zone on the backside of the fence also. In most cases the engineers have designed the areas in such a way that there is no inside transition zone either, between the fence and the interior spaces, between adjacent differing land use spaces, between spaces and structures, or between differing structures. Usually coal or other equipment and/or function yards are up against each other or the fence. The ideal situation would allow for tree massing at some distance away from the fence and between large open land use areas which might be required for construction or storage. Tree massing can be used to divide the areas and define the space, first acting to identify the space and second acting to soften the harsh industrial clutter, giving unity and order to the environment.

Color is also a factor in fencing. The best treatment tends to be light to medium gray green paint or aluminum oxidization, in areas where the primary background material will be nature's various gray-green trees, shrubs, and grasses. This tends to practically eliminate the fence as a visual element. Any reasonable color applied to a silver aluminum fence has the effect of subduing its intrusion quality.

Again it should be kept in mind that the predominant background color over which the fence will be seen, should be a major factor in selecting a color for fencing or any other structure.

However, in the case of fences at Huntington Electric Power Plant, the fence is nowhere near the property line in most cases and there is plenty of opportunity to place plant material on both sides of the fence, while still allowing the fence to be an effective barrier. (No tree trunks against the fence, etc.)

These are the major requirements of the large-scale architectural application of plant materials. Some others are:

a. articulate space

b. progressively reveal a view

c. screen unsightly areas

d. privacy control, etc.

Architectural presentation

Massed PM. Because of the huge scale of the principal structures, plant material (specifically trees) do not act on these structures the way they would on an ordinary structure (human scale). Plant material will have an effect on the micro scale of entrances, traffic modulation, privacy, etc., but one tree or a group of trees will look like the smallest shrubs to the viewer/POZ and have an overall effect of zero aesthetically. Only trees in mass can have any effect on these mammoth structures.

View modulation and goal of view modulation. Although to the power company designers, engineers and associated personnel, the power plant is the most important factor on the site, to the landscape architect in his role as the decision maker for the mass public, the total view of the environment is the important factor. Because of the large scale of the power plant principal structures, they can hardly be ignored. On the other hand the goal of the modulation of views or series of views is to present the most interesting, beautiful, and varied panoramas of the plateaus, foot hills, and canyon floor with emphasis on the contrast of the many natural elements, and of secondary priority is the contrast of the power plant elements with the natural environment (or assimilation) (blending with).

Impact of existing TOPO and PM on view modulation. The natural terrain/topography and existing plant material already do a considerable part of this view modulation. All that is necessary for the landscape architect to do is to study the existing views and perhaps add some trees to screen or direct the viewer's eye/POZ and/or adjust some of the minor land-forms or suggest grade changes in the road bed to improve the existing system.

Impact of road bed on view modulation. The gentle roll and twisting of the existing road bed coupled with the low landform of the agricultural belt, aid to do a creditable job of modulating views as one approached the power plant site from the east (the city of Huntington). The only real criticism of the existing approach is the initial two miles, starting at Huntington going west. This is pretty much of a blah view or at least lacks interest in the immediate spaces/environment, and could be changed for the better without much trouble.

Impact of scale change and view variation. The approach road does a pretty good job of modulating the view, in terms of change of scale (from far to near) and in terms of changing direction of the view from south through west to north. As one approaches the site from Huntington little glimpses are seen of parts of the plateaus and then parts of the foothills, with added interest in the immediate agricultural land contrasted against the harshness of the desert, eventually giving a broad view of the U-shaped canyon mouth and the broad canyon floor, within two miles of the site. At this point one is more or less looking up from below and feeling as small as an ant. But not all is seen until the viewer or POZ is opposite the power plant site, and as the POZ gains altitude at a slow steady pace, the forward view comes into detailed focus and the broad expanse of the desert and lower foothills lies open to the east, to the rear of the viewer/POZ.

(2) The micro scale or human scale application material as architectural modulator/modifier should be in the context of:

(a) small scale spaces where men work outside

(b) small scale spaces where men either eat or have recreation outside

(c) small scale spaces in association with the entrance and exit (access and egress) to the principal industrial structures and/or small scale structures.

(d) small scale spaces in association with the administration structure and parking for same.

Small scale spaces used by man. In these small scale spaces, it might be appropriate to introduce other than native plant material, in other words a groomed area, but in harmony with the over-all criteria/concept. In other words a semi-rough plant material will look groomed in contrast to this rough site. This would be assuming that these small scale spaces were to be irrigated, which would be the prerequisite for most other plant material.

PM modulation of view (POZ) at Huntington

Fundamentals of view modulation: direction, sequential movement, view--step dichotomy, invitation, channeling, pooling.

While all of these afore-mentioned principles apply to the architectural function of plant material, they also very fittingly apply to the use of plant material and landform to modulate and modify or direct the viewer to look at and see what the landscape architect wants him to see or to look at: the best or most interesting views. This relates to the POZ in the following way. The POZ is mobile in the majority of cases at Huntington. The major viewing will be from automobile on the road from the city of Huntington past the power plant site on into Manti La-Sal National Forest. Some or all of these principles are now in effect in many areas along the road. The only need is for the landscape architect to apply these principles further to a relatively minor degree and the resultant effect on the quality of the POZ will be terrific.

As far as the Huntington site itself, these principles apply only to roads or to the architectural structures in a minor way, entrances, parking, etc.

Orders of texture

Yoshinobu Ashihara, an architect and author of Exterior Design in Architecture, points out that there are various orders of texture.

> At a distance of 70 to 80 feet, the critical point at which unfinished concrete begins to lose its texture, the vertical concavities, which belong to a higher order of casting design, begin to exert a visual effect on the wall as a whole. From a distance of 160 feet to 200 feet the concavities located randomly become visually prominent. At a distance of 400

> feet the texture created by the concavities becomes less important, and the wall as a whole becomes centrally important. (Ashihara, 1970, p. 55, 56)

This data is from an experiment run by Mr. Ashihara. What this points out is: 1st, that further experiments should be run in order to have generally available data which applies to the effect of distance on perception at the POZ. This data should apply to all of the basic design principles that have been noted here in this thesis and perhaps others.

2nd, the way this information affects Huntington is: (a) It affects the principal structures as has been mentioned before in that only the largest of texture treatment has any effect on the POZ in this huge space and cosmic scale, (b) the perception of color, texture, etc. at the POZ is modified by the distance. Trees are seen as mass, not as branches and leaves. Of course, the immediate surroundings are perceived differently, the viewer can of course see the individual leaf that he can reach and the blades of grass in which he is standing.

The main point is that as distance increases color, scale, texture, etc., also change as perceived at the POZ. That is why detail, human scale, and groomed landscape architecture and architectural treatment are important in the limited scope of the entrances, parking areas, and other human activities areas close to the principal structures, but are useless anywhere else.

Further research. A further argument for further data gathering and study is that there are myriad materials for the environmental designer's use in creating elements for screening. Some of the elements are architecture, topography, walls, fences, sculpture, water, and plants. The most ubiquitous environmental screening elements and the ones least analyzed, and categorized or understood, for their effectiveness as screening elements, are plants. Although planting to screen ugliness or objectionable views gained wide acceptance during the highway beautification efforts of the mid-1960's, quantitative data was unavailable to show ways plants can be used to screen and what their limitations are. Available information has not been well cataloged and indexed. Guidance for the designer who would use plants for screens in an ever more crowded and cluttered world of the future is limited. How then, may plant materials be used to do this? What are the factors for consideration in using plants for masking, veiling, or screening?

Even though plants are growing, changing elements, and as such are less dependable and predictable in their density or ultimate form than are fences, walls, or architecture, they may be used in much the same way as any other screening element; they have the benefit of a natural appearance; and they have a rich inherent design characteristic because of their diversity of form, texture, and color.

When plants are used for screening, consideration is given to perceptibility of unsightliness--i.e., how much and what is ugly to an individual; or, where is the offensive view in relation to the viewer; and, what are the limits of the viewer in regard to direction, distance, and mobility. The further away an object is, the larger it must be before it becomes objectionable. On the other hand, a relatively small object close to an observer may be disagreeable and require screening. It goes without saying that a large, distant object requires relatively larger plants for screening. Close objects require denser plantings and/or closer spacing. Because of perceptual capabilities, the size of an object, area, or activity, coupled with its relative distance from the viewer, is the determining principle in screening.

Speed of movement is directly related to width of perceptability. The faster the motion, the narrower the cone of vision. Therefore, an opaque planting screen may be needed to relieve a stationary viewer from unpleasantness. By the same token, the transparency of deciduous trees in winter may be adequate for a rapidly moving viewer. The density of a plant screen may vary from extreme transparency, through translucency, to near opacity.

In summary, screening involves the isolation and sometimes the amalgamation of undesirable aspects for the purpose of obscuring unwanted views while permitting free access to the landscape.

PM for privacy control

> It is necessary to differentiate between privacy control and screening. Screening allows free access through the landscape while inhibiting certain views. Privacy control secludes a particular area from its surroundings. Planting for screening is concealing unsightly views, so that the remainder of the landscape may be opened up to unassailable human view.
>
> Planting for privacy control is secluding an area from its surrounding for special use. The same design concepts may be used either for privacy control of screening. The difference depends upon point-of-view and intent of either the viewer or the user. (Robinette, 1973, p. 28)

There is obviously applications of both of these concepts (plants for screening/and privacy control) here at Huntington, principally consciously applied only on the human scale. These concepts apply to the small/human scale only in those areas on the site where there is outside human activity and only in the confines of those spaces used (therefore principally for the power plant personnel and visitors).

On the overall site, cosmic scale, the screening principle is dominant, applying to all of the auxiliary structures. However, unconsciously, in the process of screening with mass planting and landform, the privacy control is applied automatically. Distance from the POZ, in itself, gives privacy as also the use of mass planting and landform gives privacy.

Critique--Engineering Uses

> An entire range of environmental problems are dealt with by the engineering professions. Air pollution control specialists, acoustical engineers, soil conservation specialists, traffic engineers, illuminating engineers, and sanitary and water pollution control engineers, all make significant contributions to solving pressing problems of the landscape and the total environment. . . .
>
> Parts of some plants having characteristics which permit them to solve, or help solve, engineering problems in the environment are:
>
> Fleshy leaves, deadening sound.
> Spiny branches, unpleasant to human touch.
> Spreading, clinging roots, holding soil.
> Pubescence (or hairiness) on leaves, holding dust particles.
> Stomata (or openings) in the leaves helping to interchange gases.
> Branches moving and vibrating.
> Leaves arranged to stop the fall of moisture.

> Leaves and branches slowing erosive winds.
> Dense foliage blocking light.
> Blossoms and foliage providing pleasant odors.
> Light foliage filtering light.
>
> Therefore, trees, shrubs, ground cover, and turf, may be used to control soil erosion; to control some types of excessive sound; to remove some types of pollutants from the air; to control pedestrian, vehicular, and animal traffic; and to control excessive glare and reflection. When plants are used consciously or unconsciously to perform their functions they are exploited for engineering uses. (Robinette, 1973, p. 33)

Engineering uses of plant material can be broken down into the two scale categories, but this is largely unnecessary because the engineering functions of plant material are generally equally effective in both scales.

PM control erosion

Erosion at Huntington. Mr. T. C. Byerly, Coordinator of Environmental Quality Activities, from the Department of Agriculture, Washington, D. C., has this to say about erosion at Huntington:

> . . . We wish . . . to point out that a considerable amount of vegetation and soil will be disturbed by the project with which this draft statement is concerned. Assistance in minimizing soil erosion and sedimentation during construction is available from Soil Conservation Service through local soil and water conservation districts. (Department of the Interior, 1972, p. 93)

Limiting disturbance and erosion of site. It is understood that construction requires disturbing soil and vegetation. The goal is to keep the disturbed areas as limited as possible and confined, and open to the elements for the shortest possible time. One way this can be done is to reseed with a quick growing and a slow permanent growing grass mixture, immediately after the preliminary earth work has been completed. This will hold the ground until there is time and appropriate season for heavier plant material and all construction operations are finished.

Reseeding and planting of grasses and other native PM. The fundamental guideline of mass planting at Huntington, applies to this engineering function of plant material. Reseeding of native grasses and heavier plant material is fundamental to both water and wind erosion. Mass planting obviously also applies to aesthetics.

Wind erosion--particulate matter.

> Erosion, on dry, bare earth subject to wind, causes loss of undesirable nuisance, and creating a safety hazard by reducing visibility. Climatic factors governing erosion caused by wind are wind direction, intensity, and duration. Soil factors are stability of soil crust, size of erodible soil fraction, weight of soil and amount of soil moisture. . . .
>
> Four parts of plants which control wind erosion are dense leaves or needles that create an effective barrier to air movement through the plants; dense branching that controls and slows wind close to the ground; multiple stems and rough bark that decreases wind velocity as it passes through them; and fibrous roots that grow close to the surface and effectively hold surface soil in place. (Robinette, 1973, p. 34)

1. Impact of wind on coal storage. A somewhat unusual engineering problem common to coal burning power plants is wind-born coal dust. The source is of course the coal in the storage area. The storage coal is the backlog of coal in case of a mine shut down or other emergency. A combination landform earth berm and tall plant material will create a good wind screen for the coal storage area.

2. Impact of wind on soil. Another problem on large industrial sites is ground dust. Huntington is especially susceptible to this problem due to the

low rain fall and prevailing wind combination. Once again the answer is seeding of native grass in combination with mass planting of the native pine and juniper. In places where the mass planting is impractical, such as the switch yard, combinations of earth berms and trees can be implemented for wind screens in the path of the prevailing wind.

Benefit of regional wind and water erosion control w/PM. It should be obvious at this point that anything that can be done on the site and within several miles of the site to improve the general conditions for plant material will be beneficial to the power company in improving working conditions on the site, lessening fire hazard, keeping down maintenance costs, and therefore freeing manhours for other more basic power plant functions, and especially important to the power company, improving the public image.

Regional scope of PM influence on engineering functions

Improvement should include the total canyon conditions, the nearby plateau area and even the desert to the east should be considered. This is the regional scope of the problem. The advantages to the power company in upgrading these areas is most importantly to meet immediate needs in regard to environmental pollution. The better condition and more abundant the plant material, soil conditions, and erosion control in the region, the more effective the plant material and soil can be in controlling pollution, mainly from the source of the stack emissions. As will be pointed out later in this chapter plant material is a good sink for SO_2, NO_X, and perhaps O_3. This is especially true of agricultural plant material such as legumes. Other agricultural plant material is sensitive to concentrations of these chemicals in the air and would be good for indicators in monitoring programs. In the overall view, it would be most advisable for the power company to invest interest and money and perhaps subsidize the agriculture community in the immediate area. Perhaps it would be advisable to buy the land outright and contract it out to the present owners. Further, any improvement in the quality of the grazing range located in the national forest land, will be sure to bring the cattle and sheep people to a more favorable view of the power company in general while at the same time being beneficial to the site directly in dust control-water retention and stack emission control, as mentioned before.

Acoustical control

> Noise (excessive or unwanted sound) is an increasing problem particularly in urban areas. Acoustical experts call noise invisible pollution. They have warned us that noise has increased to the point of threatening human happiness and health. (Robinette, 1973, p. 36)

Impact of PM and topo on acoustical control. Because of the vast distance involved at the Huntington site, sound is not a serious problem for the POZ or in other adjacent land use areas. However, sound may be a problem to power plant personnel, and as pointed out here by Robinette, it is a serious problem in terms of working conditions for power plant employees, because people who are not happy and are unhealthy are not good productive workers. Sound can also be a serious detriment to safety, especially at an electric power plant where safety is so important. In most cases the sound source would be inside the principal structures and therefore an architectural acoustical problem. But any work areas adjacent to these principal structures, or any work areas such as the switch yard which always has noise, can be improved acoustically (reduce noise level) and therefore the working conditions, by constructing earth berms and/or plant material sound absorbing zones.

PM and atmospheric purification

> At a time when there is much talk about air pollution and concern for our air supply, it appears that one of the greatest sources of natural atmospheric purification is being overlooked. It is appropriate to point out that plants condition and cleanse our air. Some of the ways which plants act in doing this are similar to those of commercial interior air-conditioners which heat, cool, humidify, dehumidify, clean, and circulate air. Plants control temperature, air flow, and moisture content. (Robinette, 1972, p. 50)

The engineering functions of plant material have tremendous implications for power plant site development, and particularly for Huntington, in the area of air pollution, and as has been mentioned in the area of dust and fly ash control. The precipitation and filtration functions of plant material have only just begun to be studied and understood, and shows great promise for solving the problems of power plant air pollution and almost entirely in the immediate region. It is a fact as shown by Dr. Waggoner, in his study of ozone pollution, Kalyuzhnyi, in his sulfur dioxide and nitrate oxide pollution studies, and others, that SO_2, NO_x, and O_3 can be and are controlled/contained by plant material. A little study would soon determine what plants and/or how many acres or square miles of plant material are needed to do the total job at Huntington.

PM technology: (impact on SO_z, NO_x and O_3).

> Oxygen Carbon Dioxide Cycle . Plants cleanse the air by the process of photosynthesis: in the presence of sunlight carbon dioxide is removed from the air and oxygen is returned to it. Oxygen is vital to the survival of all animals, including man, and carbon dioxide is vital to plant life. This process and interrelationship is explained by Dr. Lamont C. Cole, as follows: . . . oxygen is an abundant element and actually accounts for about half of the total mass of known terrestrial matter. However, it is a highly reactive element and is almost never found in uncombined form except in the atmosphere or dissolved in bodies of water. In both cases green plants are responsible for the presence of free oxygen. Plants take in carbon dioxide and water and use the energy of sunlight to derive the chemical reaction known as photosynthesis, which produces organic compounds and releases molecular oxygen to the environment as a by-product. . .
>
> Pollution Control. Plants control air-polluting gasses through oxygenation and dilution.
>
> Oxygenation. The introduction of excess oxygen into the atmosphere is oxygenation. The minimum ratio of air contamination acceptable to man is one part of polluted air to 3,000 parts of relatively pure air. Along many highways the ratio may be as low as 1:1,000. A one-half-mile-wide green-belt, planted on either side of freeways and expressways, would readjust the air balance. (Robinette, 1973, p. 50)

Dilution. The dilution of air is mixing fresh, or "clean" air, with polluted air. Mechanical air conditioners force fresh air into an area containing stale, impure air. Plants also mix fresh and polluted air; but rather than forcing one kind of air into another, when oxygen-enriched air is present in, around, and under them, a dilution process results. As polluted air flows around plants and through fresh air, oxygen-rich air is mixed with polluted air and is diluted. Plants also remove from the air other impurities, such as air-borne dirt, sand, fly ash, dust, pollen, smoke, odors, and fumes.

PM technology: impact on particulate M and odors. Precipitation and filtration--mechanical air conditioners filter air through mechanical filters or electrical precipitators to cleanse it. The method of electrical precipitation in air conditioning involves electrically charging air-borne particles, which also carry odors and then collecting there particles on a grid having a strong opposing electrical charge. Plants also collect air-borne particles. The leaves, branches and stems, and pubescence (hairiness) on the leaves and stems trap particles and hold them. The particles are then washed away by the rain and fall to the ground. In addition, plants act as cleaners by absorbing many gaseous and other pollutants directly into their leaves and assimilating them.

Narcosis is a temporary state of depression, and when used in regard to air conditioning, means an area relatively free of turbulence as opposed to its surroundings. This semi-void permits particles to settle out of the contaminant-laden air. A wooded area, or forest, provides such a settling chamber for air pollutants.

PM and stack emissions. It is known from Chapter IV, Environmental Impact Study, that Huntington has problems with the existing site conditions in so far as the atmosphere (air pollution) is concerned. Initially it is desirable to select a site which does not have these adverse atmospheric conditions, so that atmospheric pollution and environmental stress can be altogether avoided in the early stages. It is known, however, that the Huntington site has met, in a positive way, many other site selection design requirements or criteria. It is also known that no site is perfect and that nature is no respecter of (EPA) Environmental Protection Agency regulations as evidenced by the particulate count at Huntington, here on the edge of the desert where particulate count tends to be uniformly high.

It is a fact that the present power plant site has been selected, is under construction, and in the process of being developed. What can be done to aleviate these existing or potential problems? What function do plant materials perform that can contribute to solving these pressing problems?

As has been learned in the Environmental Impact Report, SO_2, NO_x, and O_3 are some major factors contributing to the power company's pollution concerns.

PM buffer zone or sanitary clearance zone. It is suggested that a heavy planting boarder of 500 or more meters be developed, completely surrounding the power plant site, to cut the pollution factor tremendously.

> A Russian study conducted by Kalyhuzhnyi et al. shows an enormous effect of so-called sanitary clearance zones which are green areas surrounding factories. They found that a 500 m. wide green area reduced SO_2 concentration by 70 percent and nitric oxide concentration by 67 percent. (Robinette, 1973, p. 56)

Taking advantage of existing agricultural crops. It is known that alfalfa is a good sink for NO_x.

This is an excerpt from Introduction of Tropical Legumes in the Venezualan Llanos by Jose A. Moreno.

> Legumes have been known to man from the time of earliest records. Alfalfa was among the earliest of cultivated crops, as indicated by early historical writing. . . .

> They (legumes) are capable of fixing atmospheric nitrogen through symbiotic bacteria. . . . Symbiotic bacteria (Rhizobium spp.) attack the root hairs of legume plants and the injury induces the root cell to grow around the microorganism. The injured root cell also divides to form a mass of small cells enclosing the colony of bacterial cells; these cell extensions are the nodules in which the legume bacterium lives. The legume roots supply the bacteria with the essential minerals and organic matter for energy and growth. In return, the bacteria are able to use atmospheric nitrogen to build their body proteins, which later provide nitrogen for the host. (Moreno, 1973, pp. 3-4)

Moreno (1973) points out that one practical use of legumes is as a cover crop sown for green manure. Thus legumes offer the greatest immediate contribution for improving pasture and soil fertility as well as controlling and preventing soil erosion.

So alfalfa absorbs SO_2 and NO_x, controls erosion, and fertilizes the soil, all present or potential problems at Huntington.

Impact of PM on ozone.

> Dr. Paul E. Waggoner, Chief Climatologist at the Connecticut Agricultural Experiment Station, reports on his research as follows:
>
> Our laboratory studies and subsequent computer analysis showed that plants can remove enough ozone from the air to benefit us. For example, we studied what happens when a mass of polluted air containing 150 part of ozone per billion parts of air (ppb) passes over a forest of trees 15 feet tall.
>
> We chose 150 ppb of ozone as the concentration in the polluted air because this is what we find in the air of Connecticut on a fairly polluted day. The computer analysis told us that if such an air mass stood over the forest for one hour, the air filtering down to the forest floor would have only 60 to 90 ppb of ozone remaining. The rest would have been taken up by the canopy of leaves. If the polluted air mass stood over the forest for eight hours, the air filtering down to the forest floor would have only 30 ppb of ozone left.
>
> These studies told us other things. For instance, taller trees would remove more pollution than would shorter trees. The larger the stomatal pores and the more numerous the stomata per square

inch of leaf surface, the more effective are the leaves in removing ozone from the air.

It is satisfying to learn that the plants that we like, because they are making the hills green, are cleansing our air. And it is important to discover and develop the kinds of vegetation that cleans most effectively. (Robinette, 1973, p. 54)

From the preceding, it can be seen that plants can and do function as air cleaning agents to oxygenate and remove gaseous particles and odors from the atmosphere. Plants of adequate sizes and types are effective as air cleaners. (Robinette, 1973, p. 56)

Air Washing. Growing plants transpire a considerable amount of water. A beech tree, for instance, standing alone in the open, loses 75 to 100 gallons of water during a summer day. A mature orchard transpires as much as 600 tons of water per acre per day. Plants transpire large amounts of water into the atmosphere, and cause water to form through the guttation process on their leaves, enabling them to act as air cleaners.

In mechanical air conditioning, air washers are designed to produce contact between air and water for the purposes of obtaining the transfer of heat and moisture between the two and removing impurities from the air. Moisture forming on the leaves as guttation washes particulates off them onto the ground. Moisture in suspension on and around a plant increases the humidity, and settles out wind-borne pollutants. (Robinette, 1973, pp. 51 and 52)

Impact of PM on particulate M. As already established in Dr. Hill's environmental impact study, there is considerable fly ash particulate matter in the air, as well as an unusual amount of natural dust. Both of these sources can be considerably controlled and probably totally abated by the same PM strategy (formation) as implimented for SO_2, NO_x, and O_z, the judicious use of deciduous plant material in the agricultural zone and by a dense block of native conifers plant material placed 500 meters on all sides of the principal structures (as this is the source of the particulate matter).

Trends of change (environmental protection and benefit)

In recent years, because of environmental problems, power companies have become involved in fields of competence, which at first glance, do not appear to be consistent with operations normally associated with the site development of power plants or the production of electric power.

However, Pennsylvania Power and Light (PP&L) have, in their program for transmission line and power plant site development, extended their concern into the area of fish and game and wild fowl protection and feeding, and perhaps others.

More recently PP&L has been forced to go into the operation of coal mines as have other power companies in the nation, and here at Huntington, UP&L has followed along the same lines. This, of course, is for the power industry's protection, benefit, acceptance, and pursuit of the common good.

Intent. It is the intent here to strongly suggest the very high priority that power companies should give to the consideration of investigating and perhaps entering into the agriculture and plant science business, as they have already diverged into both these other avenues of knowledge.

Recognized stress factors. It is known that Huntington is under environmental stress at this point in time, without the introduction of known additional negative factors of environmental stress associated with the normal operation of power plants.

Solution and suggested program. It is suggested that a sound agricultural, plant science program be initiated at the earliest possible date at

Huntington, to produce the maximum improvement possible, before the power plant starts production and hopefully to establish, and contribute to the improvement of the present environmental condition regarding plant material, soil make up, and the watershed. It is the intent of such a program to be continued after the start up date, through the life of the power plant (approximately 30 years).

Make up of suggested solution. Alfalfa absorbs NO_x from the atmosphere into the ground, not only purifying the air as far as NO_2 is concerned, but also enriching the soil, which in turn allows for greater crop cover and species diversity, which in turn helps to further purify the atmosphere of NO_2 and NO.

Legumes as fertilizer. The legumes contribute to fertilizing the existing plant material.

Plant material at Huntington is showing signs of stress, symptoms of disease, in various ways similar to or the same as those produced when affected by NO_2, NO, SO_2, and O_3 pollution. Fertilization improves the condition of plant material and thus helps to eliminate the majority of symptoms, if not all of them. It probably increases the resistance to these various diseases too. Improved soil conditions contributes to the same ends when combined with a vigorous spray program, thus eliminating the possible misinterpretation of these disease symptoms.

Benefit to the power company. It is important to the power companies own welfare that they recognize the critical relationship of these areas, and how they contribute to the continued uninterrupted power plant operation in the U. S., and that power companies also contribute to establishing and sustaining research and development in these particular agriculture and plant science areas to find further proof of the values and diverse application for plant material to power plant site development, and establishment of power plants in the future. If power companies don't conduct research and development to find further relationships of plant material to power plant site development, who will?

In some cases, indications are that existing power plants need to be redeveloped where this kind of development can be effective, in regard to plant material.

In Conclusion

It may be that not all criteria suggested in this thesis can be implimented, or not all criteria is applicable to all industrial sites, or can be simultaneously implimented at one site. But much of this criteria is applicable to any site at any time and can be used as a guideline, which is its purpose, and as an indication of the possibilities open to the leadership (executives, management, architects and engineers, site designers, in development and construction, etc.).

Huntington indicates a model from which to work, and develop further criteria through examination and analysis.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Criteria in Land Planning and Design--Richard Toth

> At the present time professionals in land planning and design are struggling with a particularly difficult problem of their discipline--that of SELECTING DATA AND DEVELOPING CRITERIA for the purpose of making decisions about the design and utilization of the landscape. Any design problem, from a region to a garden, MUST HAVE CRITERIA, or STANDARDS, on which judgments and actions may be based. It is impossible to design anything well without them, and it will be better if they are reached as a result of an orderly and logical process.
>
> . . . The process of separating any WHOLE INTO ITS PARTS in order to understand and define their NATURE, PROPORTION, FUNCTION, and RELATIONSHIPS is the art of analysis. In this process, the whole is separated into its parts in order to UNDERSTAND and DEFINE their ESSENTIAL QUALITY, their COMPARATIVE RELATIONS to each other with respect to size and quality, and their NORMAL or CHARACTERISTIC ACTION, including their connection through common origin or their interdependencies. Meaningful results in land planning and design will come about only if/when this process is understood and respected.
>
> . . . I think it is clear that economics and technology should not dictate the consumption of land, disregarding human and natural values. But it should be equally clear that land in itself does not dictate its own use but rather provides ascertainable opportunities for development and the satisfaction of man's needs. Furthermore, as technical and innovative construction practices and human needs evolve over time, so does the potential use, non-use, or re-use of the land. It is therefore even more necessary, when doing any planning, to understand and define the nature and function of all the parts of both the landscape and the problem under study, as well as the significance of their relationships. (Toth, 1971, p. 43) (Capitals are used for emphasis by the writer.)

The first four chapters, I, II, III, and IV have attempted to illustrate exactly this analysis and breakdown of information, first in theory and then in practice. The fifth chapter brought this multiplicity of data to bear on the case study of Huntington, in order to verify and test the site development design criteria thus identified and established in the previous chapters.

The term, principal structures, in the sense meant here means: those man-made structures which are of a size or scale to comprise the major components on the site, in relation to others on site components or structures. These are essentially elements that by their nature either in mass, height, or dominance form the major visual elements when viewed from observation (observable) points.

The basic design criterion for these principal structures is to exhibit or display them rather than hide or camouflage their appearance.

The main reason for this decision is that it is desirable to visually segregate large scale components from small scale components because when viewed together they tend to exagerate their various relative scales and appear as an unorganized jumble of incompatable components.

The principal structures of the Huntington Power Plant are: (1) stacks, (2) generating units, (3) furnace housing, and (4) the administration building.

Since it is impractical to screen these elements, with the exception of the administration building, the design element of screening is therefore not an option. One is left with the problem of how to best display or exhibit these structures in such a way as to be visually pleasing.

At the Huntington site, the principal structures can be best displayed by screening the auxiliary structures from the viewer.

In the case of placement, principal structures can be visually more pleasing when their juxtaposition is taken into consideration both in relationship to their relative position to each other and also in relationship to existing or planned landform or masses of plant material.

At Huntington there are existing landforms, mountains several thousand feet high, which in some ways dwarf or minimize the effect of the principal structures. In other words, the scale of the existing topography prohibits the principal structures from dwarfing the surrounding countryside. The overall effect of the large scale western desert space (mountains, canyons, and vast expanse of desert) is to bring cosmic scale structures into harmonious relationship with the scale of the landscape because it too is of cosmic scale.

Further design treatments of the principal structures that need to be considered are shape, color, and texture. Although there are basic requirements for the shape and size of the housing/sheathing of power plants and other principal structures, there is considerable leeway for architects and engineers in designing the outside shell. The basic requirements for the shell are: (1) to cover and protect the power plant components from the weather; (2) provide spaces for various functional and work activities; and (3) protect those men employed in the production and maintenance of the plant, both from weather and from hazardous machines and equipment.

The power plant designer is free to some degree to arrange the various interior rooms/spaces according to the best possible functional efficient relationship, much as in any other architectural endeavor. At the same time, if this activity is carried out in the best tradition of the architectural and engineering planners, the exterior shape should be visually pleasing (form follows function).

Of course the designer has at his disposal the choice of pleasing or displeasing materials; aluminum, brick, concrete, steel, etc., and each material represents a color and texture, or choice of color and texture.

The Huntington Power Plant site is far removed from the hectic pace and sophistication of urban life centers. Instead, the site is in a locality that approaches wilderness-rough and majestic. The appropriate treatment of principal structures on such sites is to blend the structures with the natural terrain as much as possible. That is to say the prevailing year round texture and color of the site especially of the soil and rock complex should be considered as the guidelines for the color and texture treatment of the structures. The emphasis should be on the summer shading as this is the time of year that the site has most exposure to the viewer. In summer, viewers are primarily tourists, fishermen, and campers. Fall brings the late tourists and hunters.

In general, the more rural the site location the more rugged in character or unfinished in appearance the industrial structures can be. The more urban the site location the more sophisticated or finished the industrial structures must be in shape and texture.

The guideline for color is to blend or be in harmony with the environmental colors and shapes. In the U.S. electrical power industry, an often used and simplistic solution has been to paint everything green or gray-green.

While gray-green is a valid solution in many parts of the country, primarily where there is heavy plant material cover with an accompanying adequate precipitation, it is not a blanket solution. It certainly is not applicable to wide regions of the western United States, especially in desert and sandy areas where a more appropriate color would be gray-brown or red-brown or yellow-gray. It appears that gray is the common denominator in all color treatments (add gray tint to the basic color) as there is a gray tint given by the atmosphere to all things seen from a distance.

An optimal color treatment is bright primary colors in urban areas (contrast) often used successfully in urban areas such as New York City and Chicago. As most power plants are in rural settings this is not a general option.

Speaking strictly from a landscape architect's point of view, auxillary structures are those structures of a small scale, many miscellaneous shapes and sizes, which if left unscreened, would contribute to the visual confusion of an industrial complex.

As was just pointed out, the large scale (principal) structures should be left exposed and emphasized or featured as the dominant man-made visual components. This can be done through the manipulation of plant material and landforms, or taking advantage of topography. Taking best advantage of existing mountainous terrain, mesas, cliffs, arroyos, gulches, benches, foot-hills, riverbeds, tree masses, and the sky line.

At the Huntington site, the bulk of the auxiliary components appear insignificant because of the large scale differential between them and the primary structures. In addition, they are seemingly randomly scattered about the site. At present, the components do not seem to have any particular planning logic to their various locations, relationships to each other (juxta-position), or overall appearance. Some of them apparently are temporary in nature. In all, this random placement creates a feeling of disunity or dis-organization. In addition, the bulk of these auxiliary components are visually displeasing, nonesthetic, their facade treatment shows little concern for unity or organization in color, texture, shape, or material.

The auxiliary structures at the Huntington Power Plant consist of: (1) fences, (2) sewage treatment plant, (3) warehouses, (4) cooling towers, (5) construction and prefab structures and fabricating areas, (6) control houses, (7) substation, (8) coal conveyor, etc.

Since these auxiliary components detract from the overall appearance of the power plant site, good design principals dictate that they be eliminated from the visual field by screening. The alternative option that would have been available in the early planning stages is grouping them to form larger design elements or perhaps underground construction could have been utilized.

It is obviously advantageous to the power company, in industrial site development, to introduce the least possible man-made objects into the environ-ment. Especially when native plant material can do the job as well or better.

The use of plant materials for these functions of course lessens the negative environmental impact.

This concept applies to all of the implimentation of plant material, Architectural, Engineering, Climatological, and Aesthetics, as well as landform implimentation.

Note: The overall goal of this plant material/landform development by the power company is two edged:

1. By improving the immediate site and surrounding region, the power plant site is benefited directly.

2. By improving the aesthetic, environmental impact, and negative aspects of the site and in combination, taking responsibility for the region round about, the public image is much enhanced and the public acceptance of further development or new development is more likely. Also the view from the POZ is improved.

This concept requires more research and development in its scientific base, as well as in prospective areas of application (soil improvement, etc.).

Recommendations

LSD Handbook of Design Criteria

It is hoped that the research data, methods, study data and design criteria compiled here will form part of a rough elementary handbook of design criteria for the landscape site development of steam electric power plants and other industrial complex developments in the U.S.

Site selection

It is further suggested that this research data and design criteria compiled in this landscape site development thesis, will also become the nucleus for criteria and guidelines for future site selection.

Strongest possible recommendation/
PM and stack emissions

The strongest possible recommendation drawn from the data and guidelines of the thesis: based on the fact that power plants produce pollution through stack emissions, construction activities, noise, smells, dust, particulate matter, chemical pollution in the atmosphere, and that the regional native plant material already existing on the site and in the surrounding area can take care of most if not all of the pollution if given reasonable study and management. The focus of this recommendation is the power industry:

1. recognize the potential of plant material

2. take steps to research, maintain, and improve upon the tremendous pollution controlling/absorbing potential of PM.

Research and development

It would be extremely helpful for future research to be focused on: first, how landscape architecture and environmental planning relates to cost in terms of industrial site development; second, broadening the existing scientific data, and making it more readily available to planners and researchers in a form useful to them.

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APPENDIXES

Appendix A: Plant Material

Plant Material List and Associated Data/Plant Material as an Environmental Indicator

Basic Plant Material List from Dr. A. Clyde Hill's Study
Associated Environmental Indicator Data from the following books:

1. Handbook of Vascular Plants Northern Wasatch, Arthur H. Holmgren
2. Handbook of the Plants of the Colorado Front, William A. Weber
3. Guide to Common Utah Plants, Stanley L. Welsh
4. Intermountain Flora, Arthur Cronquist and Arthur H. Holmgren
5. Mountain Plants of Northern Utah, Berniece A. Anderson and Arthur H. Holmgren
6. Common Native Trees of Utah, Carl M. Johnson
7. Trees and Flowering Shrubs of Yellowstone and Grand Teton, Richard J. Shaw
8. Southwest Uplands/Roadside Wildflowers, Natt N. Dodge
9. Grass Systematics, Frank W. Gould
10. Flora of Charelston Mt., Nevada, Ira W. Clokey
11. Grasses and Legumes for Soil Conservation, Soil Conservation Service, U.S.D.A.

** = Key Plant Indicator

LATIN NAME	FAMILY NAME GENUS	SPECIES	COMMON NAME	TYPE	ENVIRONMENT/CLIMATE	BOOK
PINACEAE	Pine Family					
**	a. Pinus	edulis	Pinyon Nut Pine	15 M. Low Bushy	Mesas and Foothills	2, 3, 4
				Tree 20 ft.	5000 to 7000 + ft.	6
CUPRESSACEAE	Cypress Family			12 M. 30 ft.		
**	a. Juniperus	osteosperma	Little Utah Juniper	tree/shrub	Dry Rocky Hillsides	4, 6
			Big Berry Juniper (most common tree in Utah)		4000 to 7500 ft.	
EPHERRACEAE	Ephedra Family					
	a. Ephedra	sp.	(From Wash. Co. to Uinta Basin)		4500-6600 ft.	
		E. torreyana	Mormon Tea	erect shrub 1 M.	Dry Sandy & Rocky places	3, 4,
		E. viridis	Green Ephedra	brown like shrub 1 M.	Dry Sandy places in Desert	3, 4,
			(possibly most common species in Utah)		4000 - 7500 ft. el.	
GRAMINEAE	Grass Family					
	a. Agropyron	caninum	Wheat grass			
	b. Agropyron	cristatum	Crested Wheatgrass	Grass		1, 9
		(Introduced species, used extensively in reseeding our Western ranges (1))				
	c. Avena	Fatua	Wild Oats	Grass		1, 9
	d. Bouteloua	gracilis	Blue Grama	Grass	Plains & mesas/semi arid west	2, 9
			(outstanding range forage grasses (9))		Med. & high altitude	
	e. Bromus	inermis	Smooth Brome	Grass		
		(cultivated as pasture grass/also for reseeding mountain ranges (1))				
		(road banks, earth dams, & other disturbed sites (9), very successful)				

LATIN NAME	FAMILY NAME GENUS	SPECIES	COMMON NAME	TYPE	ENVIRONMENT/CLIMATE	BOOK
GRAMINEAE	Grass Family					
	f. Bromus	Tectorum	Cheat Grass Downy Brome	Grass	Waste Places, fields, sage brush Foothills	1, 9
	g. Elymus	ambiquus	Colorado Wild Rye	Grass	Dry Slopes in the Foothills	2
	h. Hordeum	jubatum	Foxtail, Barley	Grass	Meadows, Open Ground, Waste Places Wet roadsides, Margine of Ponds, etc.	1, 2
	i. Oryzopsis	hymenodies	Indian Ricegrass (important range forage species (9))	Perennial Grass	Deserts & Rocky hillsides Semi arid regions of West	1, 9
	j. Poa	spp./longiligula	Blue Grass	Grass		2, 9, 10
	k. Stipa	Comata	Needle-and-thread	Grass	Dry hills & Plains Open woods & Sandy Soil	1, 10
LILIACEAE	Lily Family					
	a. Yucca	angustissima	Ex trel			3
SALICACEAE	Willow Family					
	a. Populus	angustifolia (erosion control or stream bank protection, wildlife food & habitate & shade for livestock or outdoor recreation sites (6))	Narrow-leaf Cottonwood	40' tree	Along water courses at low elevation Along stream banks & Canyon bottoms	1, 6
POLYGONACEAE	Buckwheat Family					
	a. Eriogonum	oralifolium	Eriogonum	Herbaceous Shrubby plants	Dry Hills	1

LATIN NAME	FAMILY NAME GENUS	SPECIES	COMMON NAME	TYPE	ENVIRONMENT/CLIMATE	BOOK
POLYGONACEAE	Buckwheat Family					
	b. Eriogonum	Simplex				? ?
CHENOPODIACEAE	Goosefoot Family					
	a. Atriplex	spp.		Weed	In Fields & Waste Places	1
RANUNCULACEAE	Buttercup Family					10
	a. Clematis	ligusticifolia	Western Virgin's Bower	Perennial climbing vine	Stream banks, growing over bushes, Plains of the Rocky Mts.	1, 8, 5
CRUCIFERAE	Mustard Family					
	a. Lipidium	spp.	Pepper-grass	Annual Perennial herb to suffruticose (woody like)	Montane	2, 10, 1
	b. Malcolmia	Africana	Malcolmia	Annual 10-40 Cen. Weed	Roadsides & Waste Places	1, 3,
	c. Sisymbrium	linifolium			Pinyon/Juniper Zone	3
ROSACEAE	Rose Family					
	a. Amelanchier (dominant shrub in Juniper and Pinyon belts (10) important to wildlife (5))	Utahensis	Koehne Service Berry	Small tree 15'	Dry Rocky Slopes More Arid Areas, Canyons, Foothills 4000-8000 ft.	10, 1, 6, 5
	b. Cercocarpus	Montanus (big game browse (6))	Rat. Alder leaf Mt. Mahogany	Shrubby evergreen	Dry Hills & Mt. Slopes	2, 1, 6

LATIN NAME	FAMILY NAME GENUS	SPECIES	COMMON NAME	TYPE	ENVIRONMENT/CLIMATE	BOOK
EUPHORBIACEAE	Spurge Family					
	a. Euphorbia (Euphorbia fendleri)	sp. (belonging to the same Genus as Poinsetia (1)) (associated w/Cercocarpus ledifolius, J. Utahensis & P. ponderosa var. Scopulorum & P.)		Weed	Fields & Waste Places	1, 10
ANACARDIACEAE	Cashew Family					
	a. Rhus	trilobata	Squaw Bush	Erect shrub 6' (Forms large clumps)	Dry Hillsides	1, 6, 5
MALVACEAE	Mallow Family					
	a. Sphaeralcea	Coccinea	Globe Mallow	Perennial herbs	Dry Hillsides Prairies & Mesas	1, 2, 3
CACTACEAE	Cactus Family					
	a. Echinocereus	triglochidiatus	Hedgehog Cactus	Large clumps Perennial		3
	b. Opuntia (Occasionally in the Juniper belt (10))	polyacantha	Prickly Pear Starvation Cactus	Sprawling plant Perennial	Dry Soil 1200-1800 M. Abundant on plains	1, 2, 3 10
	c. Sclerocactus	intermedius				
LEGUMINOSAE	Pea Family					
	a. Astragalus	spp.	Loco Weed/Milkvetch (General Species Name)	Annual/Perennial Herbs	General Dry Rocky Montane	1, 2, 3, 10
	b. Medicago	Sativa	Alfalfa, Lucerne (cultivated for hay)	Perennial Herb	Mesas	10, 3, 1, 2

LATIN NAME	FAMILY NAME GENUS	SPECIES	COMMON NAME	TYPE	ENVIRONMENT/CLIMATE	BOOK
LEGUMINOSAE	Pea Family					
	c. Melilotus	alba	White Sweet Clover			1, 10, 2, 11
	(Important cultivated legumes used for soil conservation (11)) (extensively planted for forage & erosion control (2))					
	d. Melilotus	officinalis	Yellow Sweet Clover			1, 10, 2, 11
	(Important cultivated legumes used for soil conservation (11)) (extensively planted for forage & erosion control (2))					
ONAGRACEAE	Evening Primrose Family					
	a. Oerothera	caespitosa	Evening Primrose White stemless EP	Perennial	Dry Slopes & Foothills Mesas & Canyonsides 2000 to 4000 ft.	1, 2, 10, 8
	b. Oenothera	pallida	Evening Primrose		Sandy Gravelly Soil–1000 to 7500 ft.	1, 8
APOCYNACEAE	Dogbane Family					
	a. Apocynum	spp.	Dogbane (General species name)	Erect Herbs Weedy	Mountain Sides, Dry Hillsides	1, 2, 3, 10
ASCLEPIADACEAE	Milkweed Family					
	a. Asclepias	spp.	Milkweed	Perennial Herbs		1, 2
POLEMONIACEAE	Phlox Family					
	a. Ipumopsis	aggregata				
	b. Phlox	spp.	Phlox	Perennial & Rarely Annual Herbs	Dry Hillsides & Slopes, Canyons, Rocky Places at High Elevations & Meadows	1, 2, 10

LATIN NAME	FAMILY NAME GENUS	SPECIES	COMMON NAME	TYPE	ENVIRONMENT/CLIMATE	BOOK
BORAGINACEAE	Borage Family					
	a. Cryptantha	spp.	Cryptantha (Common species name)	Annual or Perennial Herbs	Dry Gravelly or Sandy Hill or Mountain Sides	1, 10
	b. Cynoglossum	officinale	Hounds Tongue	Introduced Weed Annual Perennial	Fields & Waste Places throughout our mountains	1
	c. Lappula	redowskii	Stickseed	Annual Herbs	Dry Hillsides & Waste Places overgrazed range & Canyon bottoms	1, 10
SCROPHULARIACEAE	Figwort Family					
	a. Castilleja	linearifolia	Indian Paint Brush	Perennial/Annual	Widely distributed, washes, slopes Hilltops, Mountainsides	1, 10
CAPRIFOLIACEAE	Honeysuckle Family					
	a. Sambucus	coerulea	Elderberry Blueberry Elder	Shrubs Escaped from cultivation	Moist soil in Canyons & Hillsides Mesa-Plain, irrigated fringe	1, 2
COMPOSITAE	Composite Family (Sunflower Family)					
	a. Antennaria	parrifolia	Everlasting	Woolly Perennial Herbs	Dry open or Wooded Mountain-side, Mesas to Subalpine	1, 2
	b. Artemisia	Frigida	Pasture Sagebrush Sagebrush/Wormwood	Herbs or shrubs few inches tall	Gravelly Hillsides, Mesas to Subalpine	2
	c. Artemisia	tridentata	Sagebrush Big Sagebrush		Hills & Washes	1, 10, 2

LATIN NAME	FAMILY NAME GENUS	SPECIES	COMMON NAME	TYPE	ENVIRONMENT/CLIMATE	BOOK
COMPOSITAE	Composite Family (Sunflower Family)					
	d. Aster	glaucodes	Aster Glaucous Aster	5 mm Herb	Mountainsides, wooded slopes	1, 2
	e. Atriplex	spp. NOTE: See CHENOPODIACEAE				
	ee. Cirsium	arvense	Canada Thistle	1.5 cm Herb Noxious Weed	Fields & Waste Places	1, 2
	f. Cirsium	undulatum	Wavy-leaved thistle (Most abundant thistle on mesas and plains)	4 cm Herbs	Dry Hillsides	1, 2
	g. Chrysothammus	spp.	General name Rabbitbrush	Shrub	Dry Places in Valleys and Mountains 2,300 - 2,800 m.	1, 2, 10
	h. Erigeron	divergens	Fleabane	Herb	Gravelly Hillsides, Plains & Mesas, Meadows & Hilltops 2,670 m.	1, 2, 10
	i. Grindelia	Squarrosa	Gumplant	Perennial Herb	Roadside & Waste Places Plains & Mesas – 1,180 m.	1, 2, 10
	j. Gutierrezia	Sarothrae	Snake weed	Perennial Shrubs (Very common weed)	Plains & Mesas, Gravelly Hillsides – 1,180 - 2,700 m.	1, 2, 10, 8
	k. Aplopappus	nuttallii	General name Golden weed	Perennial Herbs Biennial Herb/Shrubs		3
	l. Machaeranthera Aster	canescens canescens			Dry Places in Valleys & Foothills	1, 2

LATIN NAME	FAMILY NAME GENUS	SPECIES	COMMON NAME	TYPE	ENVIRONMENT/CLIMATE	BOOK
COMPOSITAE	Composite Family (Sunflower Family)					
	m. Townsendia	spp. (two species)	Townsendia	Biennial or Perennial Herbs	Dry Sandy Gravelly Soil & Ridges	1, 2, 10
	n. Tragopogon	dubius	Salsify	Perennial Herbs,	Fields & Waste Places	1, 2
		(Many [100] flowered common weed found anywhere (2))				
	Machaeranthera	It appears that Machaeranthera = Aster leucanthemifolia (Greene) Pittonia				
	Aster	leucanthemifolius Greene Erythea				10
CHENOPODIACEAE	Goosefoot Family					
	a. Atriplex	spp.	Saltbrush	Annual or Perennial Herb/Weed	Fields & Waste Places, Dry Saline Soil	1, 2, 10

Appendix B: Definitions

1. Site. The area of land being developed and the surrounding land perhaps not being directly involved in development but which has been bought by the industrial corporation for a buffer or transition zone.

2. Immediate site. That piece of land being directly developed and in most cases surrounded by a cyclone fence.

3. Ground cover. The plant material from 0 to 6 inches in height, which covers the ground in mass.

4. Plant material. Any kind of plant that has potential use for conservation purposes. In this semi arid area these would be plants that can grow in non-irrigated soils and furnish wildlife feed and cover, erosion control, and cover for disturbed areas associated with industrial construction or industrial development (mining etc.).

5. Power plant. A power plant is an electric generating plant, the generation of which is derived directly or indirectly from oil, gas, water, steam, coal, or atomic energy.

6. Steam electric station. Steam electric station is an in-house term used by the electric power industry to identify coal and/or atomic powered generating plants. In both cases the generators are driven by turbines, which are in turn driven by steam which is produced by heat from atomic reaction or burning coal.

7. Fossil fuel. Fossil fuel is generally understood to be coal, although it can include oil and gas.

8. Nuclear fuel. Atomic energy or nuclear fuel is derived from the spliting of the atom. Uranium 23.5 or plutonium are the basic fuels or heat sources.

9. Design stage. That point in time when an industrial complex is being planned. Feasibility studies, plans, discussions, blueprints, and basic decisions are being made at this time.

10. Juxtaposition. Juxtaposition is the relationship of elements or components to one another and to their environment. Especially obvious in plan view or a three-dimensional model.

11. Environment. Those physical objects, elements, and components which are visible to the eye.

12. Aesthetics. The visual end result of those elements or factors that go into making a view or object pleasing to the eye. Aesthetics is based primarily on the basics of art and design.

13. Functional properties of plant materials. Properties other than aesthetics, although including aesthetics, which plant materials have, that are helpful in solving industrial development problems. Largely ignored or unnoticed by most designers, engineers, and architects. Engineering, architecture, climatology, and aesthetic properties.

14. Site development (SD). The general development, construction, and engineering that takes place on an industrial site.

15. Landscape site development (LSD). Not to be confused with site development (SD). The landscape site development deals largely with the

external functions, the physical plant itself, and its juxtaposition in space. The general environment of an industrial complex. LSD also is influenced by internal factors or functions.

16. Quantitative. A way of measuring based on numbering.

17. Qualitative. A way of measuring based on quality.

18. Quantitative studies and qualitative studies. Studies based on the methods noted above.

19. Objective. Pertaining to facts or analysis. An example: the power plant site has been denuded by bulldozer construction operations.

20. Subjective. Pertaining to personal judgement or feeling. An example: the power plant site is ugly because it has been denuded by bulldozer construction operations.

21. Fossil fuel power plants. An electric generating plant, powered by fossil fuel, usually coal.

22. POZ/primary observation zone. As explained in Chapter II, the POZ is the zone from which a person can see any element, in this case a power plant. JJ&R's POZ, for the purposes of this thesis is broken down into three horizontal zones, A, B, and BB, based on the eye level of the viewer. Zone A is the scene from eye level down to the ground level. Zone B is the scene from eye level, upward in an arc several degrees. Zone BB is a logical extension of Zone B, upward in an arc to the zenith.

23. Scale. "A standard of reference in establishing or judging a progressive graduated series. Relative proportion, size of parts compared

with the whole or with the human figure." (Smith, 1950, p. 170)

24. Proportion. "Comparative relation. Harmonic relation between parts or different things of the same kind." (Smith, 1950, p. 170)

"In the fine arts, proportion means a designed relationship of measurements. It is a ratio of intervals or of magnitudes of the same nature, kind, or class, such as time, space, length, area, angle, value, color, etc." (Graves, 1941, p. 283)

25. Composition. Is form and design.

26. Form. "The peculiar configuration by which an object is recognized by sight or touch. The appearance or character in which an idea presents itself." (Smith, 1950, p. 170)

"In the fine arts, form means man-made order, structure, design, composition, and organization, such as literary form, musical form, etc. Form is sometimes used as a synonym for bulk, mass, volume, and solid, which connotations are misleading and confusing if not incorrect." (Graves, 1941, pp. 279-280)

27. Design. "Thought, purpose, or intention as revealed in the wise correlation of parts or in the adaptation of means to an end. Purpoive planning as revealed in or referred from the art object--in the adaptation of means to an end, or the relation of parts to a whole." (Smith, 1950, p. 168)

"The art of relating or unifying contrasting elements. Man-made order, structure, composition, organization, form. The art of creating interesting units." (Graves, 1941, p. 279)

28. Congruity of form. The congruity of form as it applies to power plant site development is aimed primarily at man-made structures. (Also as a minor note, taking advantage of the already existing congruity of natural forms on the site and its environs). Congruity of form entails (1) identity, (2) similarity, and (3) conformance. This means that as a unit or units, the man-made structures should visually appear as related to each other in some way, with the emphasis on form. (Squares go together with squares, brown squares go even better with brown squares, rocky brown squares go extremely well with rocky brown squares.) This is not to say that all or even any of the squares need to be the same size.

29. Rhythm. "Movement characterized by regular measured recurrence of stress, accent, or motion. A sense of completed movement without a set beginning or end." (Smith, 1950, p. 170)

"Measured, proportional intervals." (Graves, 1941, p. 283)

30. Color. "That quality of an object by which it emits, reflects, or transmits certain rays of light and absorbs others. General effect of light with emphasis upon hue." (Smith, 1950, p. 168)

"A sensation produced by excitation of the eye by various stimuli such as light, drugs, pressure, or electricity." (Graves, 1941, p. 276)

**The following: as defined in the Random House Dictionary and Landscape Vocabulary by Warner L. Marsh, 1964. Random House Dictionary = RH and Landscape Vocabulary = LV.

31. Physiography.

(1) the science of physical geography. (2) U. S. geomorphology. (3) the systematic description of nature in general. (RH)

A branch of geography which deals with the total physical environment of the earth. Physiography is concerned with the interactions of the sciences of climatology, oceanography, and geomorphology. (LV)

32. Geomorphology.

The study of the characteristics, origin, and development of land forms. (RH)

A branch of geology which deals with the study of land forms--the structure and evolution of the landscape. An understanding of geomorphology can be of considerable use to the landscape architect concerned with the problems of grading, soil erosion and management, and conservation and evaluation of scenery. (LV)

33. Geography.

(1) the science dealing with the areal differentiation of the earth's surface, as shown in the character, arrangement, and interrelations over the world of such elements as climate, elevation, soil, vegetation, population, land use, industries, or states, and of the unit areas formed by the complex of these individual elements. (4) the topographical features of a region, usually of the earth, sometimes of the plants. (RH)

A broad science which concerns itself with the relationship between life on this earth and the physical environment or physiography. In its broad sense, the term is synonymous with ecology, also understood in its broad sense. For accurate usage, both terms should be limited or qualified by adjectives.

Geography, in general, includes the following branches of science: (1) economic geography, which deals with the relationships between economics and physiography; (2) military geography, which deals with the relationships between military science and physiography; (3) political geography, which deals with the relationships between history or government and physiography.

The science of homo-ecology, likewise, deals with the relationships of man's activities--economic, military, and political--to the physical environment or physiography. While geography and ecology deal with the same subject material, there is a distinct difference in the viewpoint of practitioners of these disciplines. Geographers are more concerned with the natural histories of man, of other organisms, and of the physical environment as explanations of present status. Ecologists are concerned with understanding evolution and present status as keys to future evolution. There is obviously room for both viewpoints in the world of science. The landscape architect is a practicing ecologist, whether he is aware of it or not. A grasp of the principles involved will enable him to refine his art and to increase his efficiency as an agent of social change and progress. (LV)

34. Topography.

(1) the detailed mapping or charting of the features of a relatively small area, district, or locality. (3) the relief features or surface configuration of an area. (5) a scheme of a structural entity, as of the mind, field of study, society, etc., reflecting a division into distinct areas having a specific relation or a specific position relative to one another. (RH)

A term applied to the surface features or relief of the earth, or to a graphic description of these features. (LV)

35. Topographic factor.

In ecology, a characteristic of the topographic environment, such as elevation, orientation, steepness of slope, etc., which limits the development or existence of an organism or community of organisms. Also called a physiographic factor. (LV)

**End Random House and Landscape Vocabulary.

Elements of order

36. Sequence. Spaces are experienced by persons moving through them. The observer, in analyzing existing spaces, may find a planned sequence to be a very strong organizational device. Sequence is continuity in perception of spaces or objects arranged to provide a succession of visual change. It may create motion, a specific mood, or give direction. Each element in a sequence should lead to the next without necessarily revealing it.

37. Repetition and rhythm. The simplest kind of sequence is repetition, which may involve color, texture, and shape: however, only a single factor must be reiterated for it to occur.

If a sequence of repetitive elements in interrupted at recurring intervals, rhythm is established. Rhythm gives variety in contrast to total repetition, which may prove monotonous. An example in an existing paving pattern would be the recurrence of brick bands between concrete squares.

38. Balance. The next element of order is balance. Are the objects in a space in symmetrical or asymmetrical balance? In symmetry equal and like elements are balanced on either side of an axis. Asymmetry is the balance of unequal and unlike elements on opposite sides of an axis. In occult balance an optical axis or center of gravity is implied and opposing elements may be symmetrical or asymmetrical. An example of asymmetrical occult balance would be trees appearing to balance a hill on an implied visual axis. When opposing elements or structures develop tension among themselves, so that there seems to be a total balance of the elements along with the surrounding space, a dynamic form of balance has occurred.(Rubenstein, 1969, pp. 69-70).

Characteristics of objects in the landscape

39. Shape, size, scale. The characteristics of objects in the landscape determine the quality of a space and its enclosure. What is the shape or form of the space? Is it rectilinear, curvilinear, or triangular? What is the the size of the space? The size of an object or space is relative; it is large or small according to the standard with which it is conpared. Size also depends

on the distance of an object from the observer, whereas scale denotes relative size. Scale is therefore generally based on the size of the average observer--5 feet 9 inches.

40. Proportion. Proportion is also a most important design factor. It is the ratio of height to width to length and may be studied in drawings or models. Shape, size, scale, and proportion in the formation of structures or spaces must be considered in design. In planning future expansion of an existing project these elements must also be studied to prevent disruption of existing areas.

41. Texture and color. Whenever one cannot determine the size and shape of specific parts as they form a continuous surface, there is texture, which may be preceived by touch or by sight. All materials used on a project have texture whether they are rough surfaced granite or smooth polished marble. Inherent in the use of materials is color. On expansion of existing projects try to match existing materials in color and texture to achieve harmony.

42. Hierarchy. Hierarchy may be used to rank sizes or colors. For example, a hierarchy in the sizes of spaces is a sequence of spaces which progressively change in size of importance until one comes to a dominant or central space. Another example of hierarchy is its use in determining the width of walks according to the volumes of pedestrian traffic anticipated. The third example is in ranking colors of paving materials to give added importance to a dominant feature within a space, such as a fountain or sculpture. Often a darker colored material is used as a subtle transition to emphasize the paving around the feature (Rubenstein, 1969, pp. 70-71).

43. Volumes and enclosure. To achieve clearly defined spaces, consider enclosure or space-forming elements and the volumes contained by the space. Exterior volumes are formed by three enclosing or space-forming elements--the base plane, the overhead plane, and the vertical plane.

44. Base plane. The base plane is our greatest concern in determining land use. It is the surface of the earth and therefore must be properly planned for uses and their linkages before further development can take place. Through treatment of the base plane, one relates and articulates all elements on its surface. A strong land use plan must exist beforehand.

45. Overhead plane. The sky is our greatest overhead plane. Man-made planes may be used for further definition in the height of a space. Overhead planes may be solid, translucent, or perforated, but this is generally not as important visually as the type of articulation they provide.

46. Vertical plane. Vertical planes have the most important function in articulating the uses of spaces. Buildings are usually the dominant vertical elements that articulate space and with which the site planner must work. The placement on these buildings and other vertical elements will determine the degree of enclosure of a space.

Vertical elements also have great visual impact and may act as points of reference or landmarks. A vertical element such as a sculpture may also become the dominant feature within a volume. Vertical planes can act as screens to eliminate objectionable views, thereby enframing good views. These planes also serve as buffering elements for noise in the form of plant material and they may control sunlight or wind (Rubenstein, 1969, pp. 71-72).

Appendix C: Factual Data Concerning

Huntington Power Plant

Most of the land on which the Station is being constructed was owned by the Utah State Division of Wildlife Resources. A 36-acre tract is under the jurisdiction of the Bureau of Land Management. A small part is privately owned. The Company has a contract with the Utah State Division of Wildlife Resources to exchange the Station site land for other lands, and the land has been deeded to Utah Power and Light Company. BLM has issued a permit for use of the tract under its jurisdiction. Arrangements are under way to transfer this tract to the State of Utah as lieu land, and the Company would then purchase it from the State. . . .

Water to be utilized by the Company would be procured under three separate arrangements:

1. By proposed contract with the Department of Interior and Emery Water Conservancy District. This water was originally developed by the Department of Interior to provide supplemental irrigation water to existing irrigated land in the area.

2. From irrigation water rights acquired by the Company from individual landowners in the area.

3. Water rights granted to the Company by the Utah State Engineer. (Department of Interior, 1972, p. 1)

The first two categories may eventually result in the retirement of some irrigated lands in the area. The relinquishment of both Emery County Project water and individual water rights was negotiated by Company officials with individual water users and the Emery County Water Conservancy District. Amounts of both categories of water relinquished were optional and voluntary on the part of each individual and the District Utah Power and Light paid a flat fee for individual water rights, and has agreed to pay the Emery Water Conservancy District at M&I rates for all water converted from irrigation to generating station use for the 6,000 acre-feet of Emery County Project water supply. It is estimated that the equivalent of as much as 4,400 acres of land could be removed from production as a result of the conversion to M&T use. Very few farmers relinquished their entire water supply. Some of the water being acquired by the Company has been used on land which does not conform to Interior Department standards for irrigable lands. It is likely that individual farmers will relinquish water from these substandard lands and concentrate their remaining supply on higher quality and more productive lands.

Cooling water/Electric lake

Cooling water will be taken from Huntington Creed to a settling basin before being used as make up in the cooling system. An upstream reservoir of about 30,000-acre-foot capacity [unfortunately named Electric Lake] will provide a supplemental water supply. The upper part of the reservoir area (Electric Lake), about 40 acres, is National Forest land, and an application for use of this land is pending. The lower reservoir area is owned by the Company. This reservoir will be about 4 1/2 miles long and 215 feet deep at the dam. Discussions are continuing among the Company, Utah State Department of Natural Resources, and the Forest Service to plan the most beneficial development and use of the reservoir area for recreation. Relocation of Forest Highway Route & (State Route 31) will be required as part of the construction of water storage and supply facilities. (Department of Interior, 1972, p. 5)

Coal mine

Fuel for the Station will be coal from an underground mine, to be operated by the Peabody Coal Company, about 2 1/2 miles from the Station. The mine is located on lands owned or leased by the Company within the boundaries of the Manti-La Sal National Forest. Coal will be mined by underground methods from two major seams. The thickness of the Hiawatha seam explored is about 10 to 13 feet. The underground mine will employ bolted-roof protection with sidewall cribbing where necessary. The Company anticipates that there will be no excess water during the mining operation; but if excess water is encountered, it will be directed to settling ponds for Station use, or to evaporation ponds. The coal will be conveyed to the Station as mine run. No washing will take place at the mine. Coal will be transported to the Station by covered conveyor. Average coal consumption is estimated at 1 million tons per year for a 430-megawatt (MW) unit. Coal reserves are estimated to be sufficient for a 2,000-megawatt (MW) Station for its projected 35-year life.

Transmission line

Energy from the initial unit will be transmitted principally over a 345-kilovolt (KV) line to Camp Williams, near Salt Lake City, Utah, and to the Four Corners Area, where it interconnects with the Arizona Public Service Company system. The line was completed as a part of the Company's system in June 1971. . . . In a letter of January 21, 1972, the Federal Power Commission commented as follows on this transmission line:

> The prime market for the power from the Huntington Canyon Generating Station is the Salt Lake City load center of the Applicant's service area where approximately 70 percent of the Applicant's load is concentrated. The peak load of this area in

> 1970 was 880 megawatts and is expected to grow to 1,760 megawatts in 1980 and 3,540 megawatts in 1990. Thus the 345-kilovolt transmission line running northwest about 160 miles to the Salt Lake City load center is a necessary consequence of the Company's decision to construct a mine-mouth plant at the Huntington Canyon site.
>
> The section of 345-kilovolt transmission line running southwest approximately 250 miles to the Four Corners Area will strengthen the interconnections between the systems of the Pacific Northwest and those of the Pacific Southwest and contribute to the general interchange capability and improve stability of the western bulk power transmission network. These considerations lead us to conclude that both branches of the 345-kilovolt transmission line stretching northwest and southeast of the Huntington Canyon Generating Station are important components of the proposed generating facility which will have a beneficial influence on the stability of the entire western transmission network, particularly in the area along the eastern side of the north-south loop. (Department of Interior, 1972, p. 6)

Additional transmission capacity will be required as generating units (after the first 430-MW unit) are brought on line. The location and approval of right-of-way for these additional lines will be considered by the Department of Interior at the time they are proposed for construction and the Department's consideration will be based on Environmental Statements covering the additional units and transmission lines prepared prior to the time Federal actions are requested. It would be impossible for the Company to build additional transmission lines from Huntington Canyon without crossing public lands so additional units must have the concurrence of the Department of Interior and probably of the Department of Agriculture (U. S. F. S.). (Department of Interior, 1972, p. 7)

Utah Power and Light Company began study of possible sites . . . as early as 1967. These efforts became urgent . . . early in 1968 when it became apparent that additional energy would be required for the Company's interconnected system by 1974. The availability of coal and water was first investigated in 1967, and this investigation continued through the remainder of 1968. A letter of intent covering coal purchases was executed in September 1969. With the assurance that coal and water were available in sufficient quantities in Huntington Canyon, efforts were pressed for the preparation of plans for the Station, for the reservoir, and for the transmission line. (Department of Interior, 1972, p. 8)

As of December 31, 1971, the Company had expended about $37 million in construction of the Station and transmission line. Total commitments on the Station alone through January 1972, in addition to those expenditures, amounted to $43.5 million. Total $80.5 million at that time. (Department of Interior, 1972, p. 9)

Socio-economic factors

The Station will provide a significant economic impact in the Carbon and Emery County areas.

The construction force is expected to peak out at approximately 500 men during the construction of the first unit. In 1974 when the 430-megawatt (MW) unit begins generating electricity, 44 men will operate the Station. The mining operation serving the Station is expected to require approximately 200 men by 1974.

In addition to added employment, the first unit alone will double the tax base of Emery County. In 1970, the Company paid $54,719 in property taxes to the County. The amount will jump to some $710,000 in 1973, and when the first unit of the Station is completed in 1974, property taxes are expected to be over $1 million per year. Additional units, as constructed, will provide proportional increases in the economy of the County. (Department of Interior, 1972, p. 20)

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